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Heating · Piping and Air Conditioning

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ercial, Industrial
Large Buildings

April, 1940

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Journal Section
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ilating Engineers

Methods of installing unit heaters in order to prevent cold drafts at building, store and restaurant entrances is one of the subjects discussed this month. There are also articles on the heating of Rockefeller Center, power piping drafting, Walt Disney's new air conditioned studios, smoke elimination, improving plant heating, corrosion, the psychrometric chart, welded connections, and others

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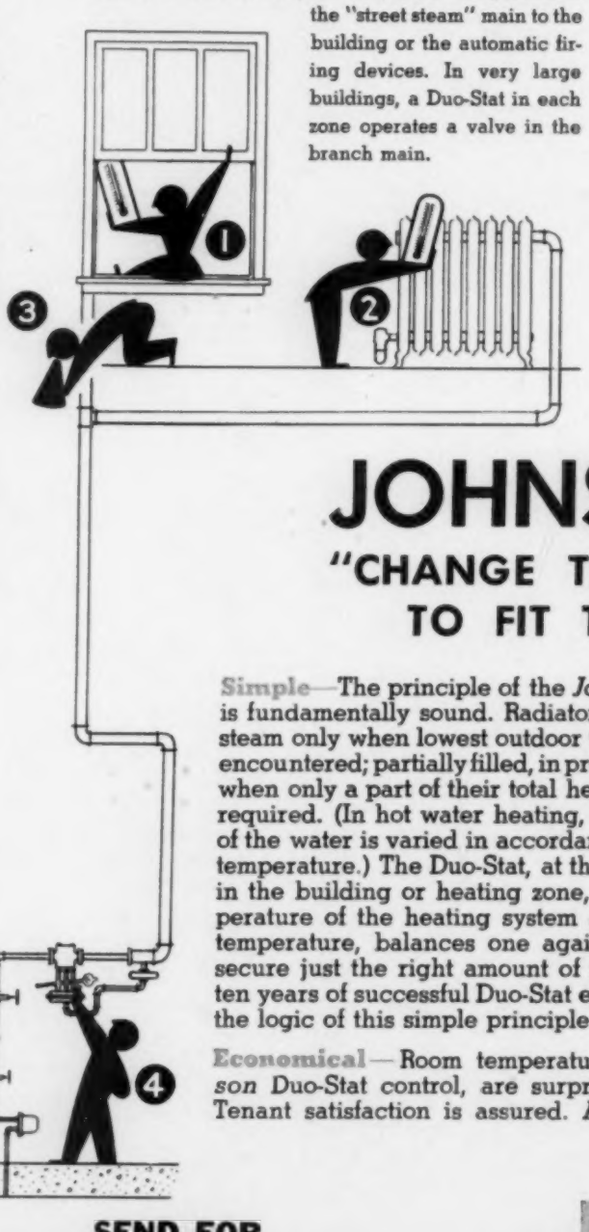

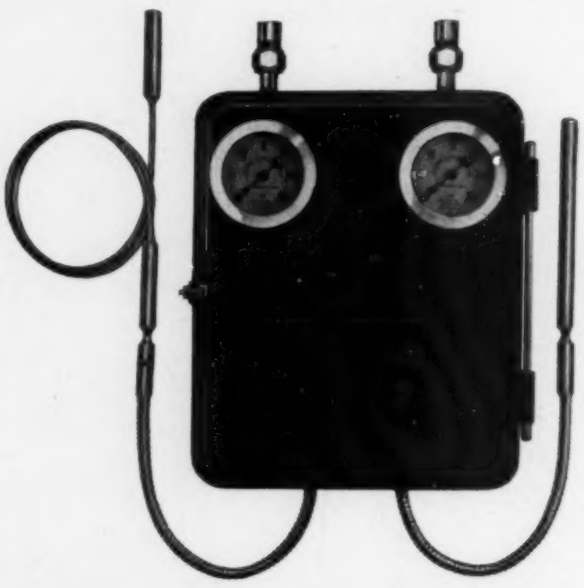

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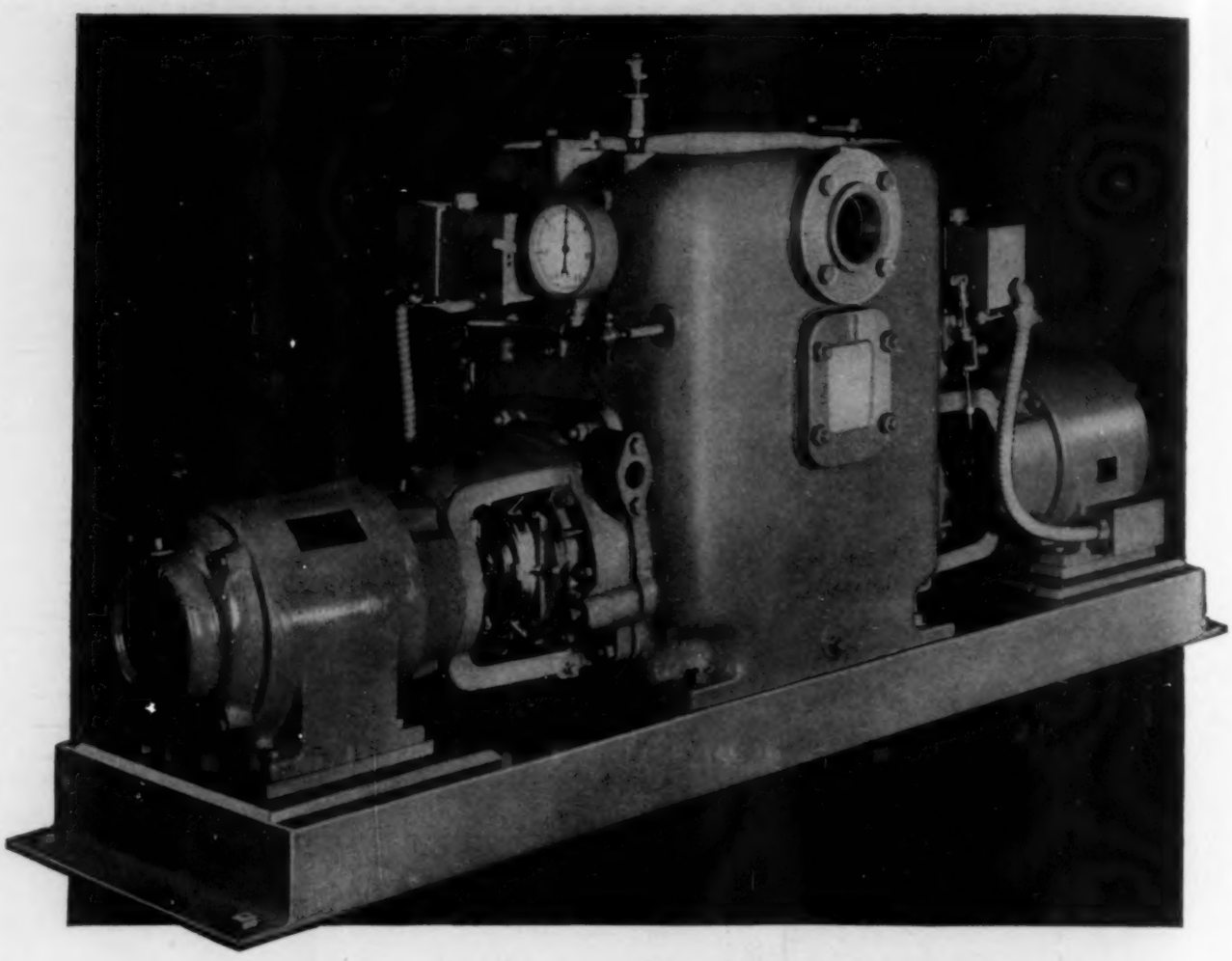

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THE EDITOR'S PAGES

WE RISE TO A POINT OF ORDER

A service like air conditioning, essential as it is to the comfort and well-being of almost everyone, comes in for a lot of discussion by "the butcher, the baker, the candlestick maker" because of its very importance. No one is without an opinion of air conditioning, as may easily be observed every time one walks into a club car, hotel lobby, restaurant or cocktail party. Although "experting" on military and naval strategy has in recent months probably put air conditioning in second place as a conversational topic, it still holds its own as a subject of general comment and discussion.

This wide interest in air conditioning on the part of the general public is a healthy sign. Doubtless when one of our early forbears moved into the first cave, all his neighbors could speak with authority on the advantages and disadvantages of living in caves.

We can't agree with the chorus girl, however, that publicity—whether it be good or bad—is valuable. In a political item, one of the news magazines recently took a crack at the "wet chill" of an air conditioned office. The remark seems entirely out of place to the editors of HPAC for several reasons, not the least important of which is that nobody seems to know what the basis for it was in the first place. But suppose on some occasion the operation or adjustment of this particular air conditioning installation was not all that it should be? Certainly this is no condemnation of air conditioning as such. Such things are easily made right.

It seems to us that those who speak on air conditioning should explain the reason for their views in full, and not be permitted to generalize unchallenged.

OWNERS TELL HOW AIR CONDITIONING BENEFITS

A few comments of users of air conditioning on its benefits were given in a recent issue of the "Air Conditioning News," a bulletin published by Philadelphia Electric Co.

According to the owner and manager of an air conditioned restaurant, his investigations have convinced him that people come more often, stay longer and eat more in an air conditioned restaurant. An optician comments that he is certain air conditioning is one of the best investments, both in comfort and advertising, he has ever made. The manager of a jewelry store says that his aim in installing air conditioning was to make shopping more comfortable and assist the personnel in maintaining the fresh, immaculate appearance so essential in the jewelry business; both objectives were attained.

The proprietor of a hosiery store remarks that the primary objective in air conditioning the store was to provide comfortable surroundings in which women may make their selections, but another factor of considerable importance has resulted—the reduction in soilage of the perishable merchandise by perspiring hands. The manager of another Philadelphia store where additional air conditioning was installed in 1939 is so thoroughly convinced of its drawing power that he insists it be used in all of the store's advertising.

BIG CHICAGO JOBS REPORTED

There were 28 Chicago air conditioning installations sold during the month of February, 1940, according to the Commonwealth Edison Co., totaling 1313.25 tons and 1617.75 hp. Twenty of these jobs, accounting for 1303.5 tons and 1608 hp, were of the central plant type, and eight were room cooler installations.

Largest of the installations was a 500 ton, 590 hp job for the Merchandise Mart. Other large ones included the 400 ton, 556 hp installation for the Equitable Life building, the 100 ton, 125 hp job for the General Electric building, and the 80 ton, 102.5 hp installation for the Underwriters' Laboratories.

OHIO STATE ANNOUNCES WELDING COURSE

Ohio State University established a year ago a four year curriculum in welding engineering to meet the apparent need for collegiate education in this field. The course draws together the basic sciences necessary in the training of an engineer for service involving the use of welding.

After the inception of this course, the welding division of the industrial engineering department, which administers the course, discovered that there were many practicing engineers who needed basic training for welding engineering. Accordingly, a special three day short course in welding engineering has been scheduled for April 16-18. During these three days, three classes will be held daily on such subjects as welded joints, fundamental mechanics, welding symbols, production welding, etc. In the case of welded joints, several classes will be devoted to this subject covering it progressively. Lectures will be given by prominent engineers in the welding field, as well as by members of the university staff.

Information on this course is obtainable by writing J. R. Stitt, Assistant Professor, Welding Engineering, Ohio State University, Columbus, Ohio.

AIR CONDITIONING OBJECTIVE DEFINED

The air conditioning industries branch of the board of trade of the city of Toronto, Canada, has adopted a memorandum setting forth the objective and definition of air conditioning for comfort with the hope of educating the general public to recognize what functions should be performed by air conditioning equipment.

The memorandum as adopted by this body follows:

Objective—Air conditioning for human comfort has for its objective the maintenance of such atmospheric conditions as will produce desired effects upon the occupants of a structure.

Definition—Air conditioning for human comfort is defined as the simultaneous control within any structure of the temperature, humidity and circulation of the atmosphere therein; it shall also include an adequate supply of air from outside such structure, and may include the control of any other factors affecting either or both the physical and chemical conditions of the atmosphere within the structure.

Apparatus—Air conditioning apparatus, in order to comply with the above definition, shall be capable of performing as a minimum the following functions:

Summer air conditioning—(1) Cool the air. (2) Dehumidify the air. (3) Circulate the air.

Winter air conditioning—(1) Heat the air. (2) Humidify the air. (4) Circulate the air.

Year 'round air conditioning—(1) Cool and dehumidify the air in summer. (2) Heat and humidify the air in winter. (3) Circulate the air.

Most air conditioning apparatus, in addition, cleans the air.

USHA LOAN CONTRACTS PASS $600,000,000

Loan contracts to local housing authorities for construction of low rent projects to rehouse low income families passed the $600,000,000 mark last month when President Roosevelt upon recommendation of Nathan Straus, Administrator of the United States Housing Authority, approved loans totaling $27,236,000 for 13 communities.

These loans, to defray 90 per cent of the estimated cost of 18 low rent and slum clearance projects, brought the total of USHA loans approved to $624,114,000 for 158 local housing authorities throughout the nation. Their programs call for the erection of 379 projects in 167 different communities and provide a total of 140,242 dwelling units for 560,000 tenants. Earmarkings outstanding for further loans total $52,212,000, which with the $624,114,000 in approved loan contracts, makes a total of $676,326,000 in USHA commitments to 178 local housing authorities.

To date, 184 USHA aided projects totaling 71,699 dwelling units have gone under construction, or have been completed, in 25 states, the District of Columbia, the Territory of Hawaii and Puerto Rico.

MAY WE HAVE YOUR HELP?

An increase in the number of requests from readers of Heating, Piping and Air Conditioning for references to published material on various subjects and extra copies of articles which have appeared in our pages indicates that many of our subscribers maintain files for permanent use. The editors are endeavoring to make a study of the ways in which back copies of HPAC are preserved for reference, and would appreciate the help of all readers who follow some regular monthly procedure of this kind. The object of the survey is to determine if the form in which our articles now appear is the most convenient for the majority, or if any changes in their general arrangement should be made to facilitate future reference to them.

Do you maintain some form of filing system for referring to articles which have been published in HPAC? Do you make use of our volume index for the year which is published in each December issue? Do you preserve your back copies of HPAC intact, are they bound in volumes, or how are they kept? What types of articles do you generally want to keep for future use? Answers to these and similar questions will be of considerable assistance to us.

You will note that each of our articles this month is summarized more extensively than has been the case in the past, the summary appearing in a "box" right with the article. It is hoped that readers will find these editorial summaries of value and that they will add to the usefulness of each month's contents.

AIR CONDITIONING EXPORTS RISE

Shipments abroad of American air conditioning equipment in 1939 were valued at $2,134,655, a gain of 27 per cent over the corresponding trade in 1938, the machinery division of the Department of Commerce reported last month. Self-contained air conditioning units comprised about one-third of the trade in both years, and other types the remaining two-thirds.

Exports to Asiatic markets represented 44 per cent of the total shipment to all countries.

HOTELS REPORT ON AIR CONDITIONING

Comments from its readers on the benefits of hotel air conditioning were recently obtained by the magazine *Hotel Management* in response to a questionnaire. According to one hotel man, 70 per cent of his summer business is repeat business, which compares with only about 50 per cent before he air conditioned. His summer house count with air conditioning averages 87 per cent, whereas before it ran around 63 to 65 per cent. Check averages and restaurant business also increased.

MODERN INDUSTRIAL PIONEERS HONORED

The names of several of the "modern industrial pioneers" honored by the National Association of Manufacturers in connection with the celebration of the 150th anniversary of the American patent system were mentioned on this page last month. Since that time, a complete list of those inventors and research workers on modern industrial frontiers who were given recognition by the association has been made available.

Many of the modern pioneers are known in the heating, piping and air conditioning field. In addition to those mentioned last month, the group of "national modern pioneers" includes William David Coolidge of General Electric Co., Frederick Gardner Cottrell, George Oliver Curme, Jr., of Carbide and Carbon Chemicals Corp., John Van Nostrand Dorr of Dorr Co., Inc., Irving Langmuir of General Electric Co., John B. Tytus of American Rolling Mill Co., and Charles Frederick Wallace of Wallace & Tiernan Co., Inc.

In the New York area the following were honored: William Nelson Goodwin, Jr. of Weston Electrical Instrument Corp., Max Spillmann of Worthington Pump and Machinery Corp., Thomas Canning McBride of Worthington Pump and Machinery Corp. and O. B. Hanson of National Broadcasting Co.

In the Baltimore area William B. Hodge of Parks-Cramer Co. was honored.

In the Boston area, the following were honored: John H. Ashbaugh of Westinghouse Electric & Mfg. Co., Harold E. Edgerton of Massachusetts Institute of Technology, Harold Frederick Hagen of B. F. Sturtevant Co., Clesson E. Mason of the Foxboro Co., and Edward R. Wolfert of Westinghouse Electric & Mfg. Co.

In the Chicago area the following were honored: Ray C. Newhouse of Allis-Chalmers Mfg. Co., William Halvor Taylor of Vilter Mfg. Co., and William M. White of Allis-Chalmers Mfg. Co.

In the Cincinnati area, the following were honored: Harold William Greider of Philip Carey Mfg. Co., and Games Slayter of Owens-Corning Fiberglas Corp.

In the Cleveland area, the following were honored: Frank Conrad of Westinghouse Electric & Mfg. Co., Ralph Emmons Hall of Hall Laboratories, Inc., James Finney Lincoln and John Cromwell Lincoln of the Lincoln Electric Co., and Marvin Pipkin of General Electric Co.

In the Detroit area, the following were honored: Royce Louane Beers of Detroit Stoker Co. and Thomas Midgley of Ethyl Gasoline Corp.

In the Hartford area, Edward Payson Bullard, Jr. and Thomas Edwin Dunn of the Bullard Co. were honored.

In the Minneapolis area Frederick S. Denison of Minneapolis-Honeywell Regulator was honored.

Thomas Randolph Harrison of the Brown Instrument Co. was honored in the Philadelphia area.

Albert A. Criqui of Buffalo Forge Co. and Frederick William von Meister of Ozalid Corp. were honored in the Rochester area.

Albert Riley Thompson of Food Machinery Corp. was honored in the San Francisco area.

In the St. Louis area the following were honored: Burns Dick of Wagner Electric Corp., Edwin F. Guth of Edwin F. Guth Co., William D. Moore of American Cast Iron Pipe Co., Edwin S. Pillsbury of Century Electric Co., and Hans Weichsel of Wagner Electric Corp.

Heating · Piping and Air Conditioning

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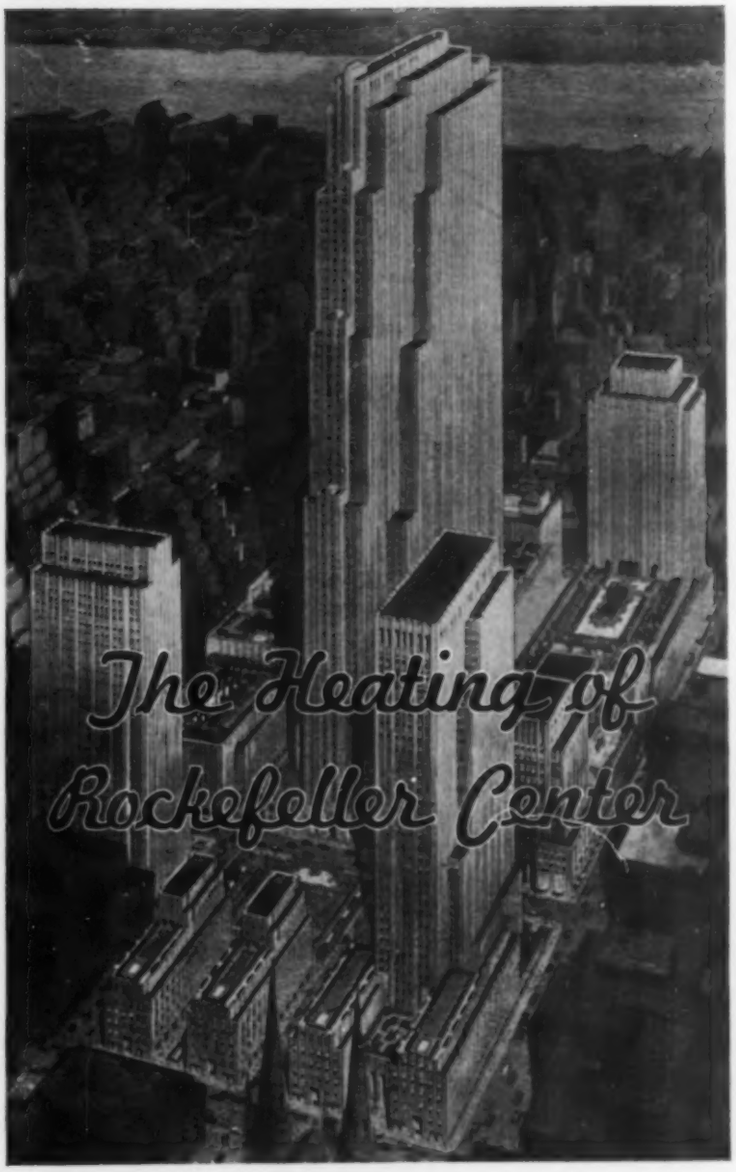


The Heating of Rockefeller Center

By J. H. Rawson and C. W. Walton, Jr.*

THE heating requirements of the several buildings of Rockefeller Center present a problem of combining large scale operation with flexibility to meet ever-changing conditions and special demands. Two comparatively small buildings of six floors, well protected by surrounding structures, represent one extreme in size. The other extreme is a huge building of 70 floors, fully exposed to severe weather conditions as well as subject to the chimney effect inherent in all enclosures of great height. The heating demands vary from daytime temperatures suitable for office workers through adequate conditions for night workers to such individual operations as full heat supply to the Rainbow room until 3 a. m. There are other special needs calling for extra heating regularly or on special occasions; hence close attention must be paid to scheduling in order to meet demands economically.

Although most of the buildings are connected below the street level where the loading platforms surround a trucking area, each structure is a separate unit in respect to its heating and ventilating facilities. This is true of most of the mechanical and electrical services with the exception of the refrigeration plants for air conditioning.

The heating equipment in all of the office buildings includes the sub-atmospheric system of steam distribution and control; the basic characteristic of the system is the use of a differential control on a high vacuum pump which maintains a definite pressure difference between supply and return mains. A few relatively small portions of the development have other types of vacuum heating systems and some are dependent upon their air conditioning systems for meeting the heating requirements.

All steam used at the Center is purchased from the New York Steam Corp. In the larger buildings steam supplies are brought in from two different street mains on opposite sides of the building; the smaller buildings have single supply lines. This steam is supplied at 125-130 lb pressure, but is immediately reduced to 90 lb after the flow is measured through meters. From 90 lb headers the steam is further reduced to 50, 40 and 10 lb to meet the many heating and miscellaneous demands. Ten lb lines supply the water heaters, ventilating stacks, air conditioning heaters and other equipment in basements. Forty lb lines are kept in service all year and supply steam to utility risers in those buildings having auxiliary equipment situated above the basement; steam is taken from these 40 lb risers through reducing valves and fed to air conditioning heaters, water heaters, ventilating heaters and kitchens. All of the buildings have 50 lb risers for direct radiation which are operated from late September until some time in May. The 50 lb riser in each building provides steam for various distribution points or pressure reducing valve rooms, as will be explained later.

*Mechanical Engineer, Rockefeller Center, Inc.

Zoning the Buildings

Before tracing through the 50 lb riser, it will be well to describe the method of dividing a building into zones to obtain a balanced temperature despite differences in outdoor temperatures at various floor levels, or at the same level on opposite sides of the building. The heating systems are designed with sufficient flexibility to

The Heating of Rockefeller Center

By J. H. Rawson and C. W. Walton, Jr.

Occupying most of the area between Fifth and Sixth Aves. and West 48th and 51st Sts. in New York City, Rockefeller Center spreads over more than 500,000 sq ft, has a floor area of over 5,000,000 sq ft, a population of 25,000 and 125,000 visitors every working day. Some of the heating and air conditioning installations for parts of this mammoth building project have been described before in these pages; this year, however, will mark the completion of the original concept of the Center; thus it is timely to review the complete story. . . . The heating of the Center is described this month, and later articles on the air conditioning and refrigeration are planned. The problem presented was that of combining large scale operation with flexibility to meet ever-changing conditions and special demands. Sub-atmospheric steam under careful control is the heating method employed, steam being purchased from the New York Steam Corp. at 125-130 lb, reduced first to 90 lb and then to 50, 40 and 10 lb pressure to meet the various demands. The buildings are zoned vertically and horizontally. Radiation is of the copper tube and fin convection type. The main control valve for each zone is actuated by three distinct controls—the thermostats, heat balancers, and selectors; the thermostatic control comprises a group of four to nine thermostats connected in series and situated throughout a particular zone, the heat balancer is a thermostatic arrangement to measure the heat output of a typical radiator, and the heat selector is a thermostatic arrangement placed against the inside face of a window in the zone and whose action is dependent upon the rate of heat loss through the glass. . . . A minimum temperature of 73 F is maintained in the buildings during hours of the regular occupancy; this is reduced to 65 F at night

fulfill the demand for heat in one or more portions of a building without overheating other portions. This is accomplished by dividing the building into heating zones.

Quite naturally, the heat requirements of a northern exposure usually differ from a southern exposure, hence most buildings are divided into northern and southern zones. In the smaller units, such as the British Empire building and La Maison Francaise, these two zones are adequate. The taller buildings are also zoned to compensate for lack of protection afforded by surrounding structures, and at still higher levels for the unpredictable effects of high winds. These vertical zones vary in extent from five to 20 floors. In addition, special heating requirements in one portion of a building, as the Rainbow room or the broadcasting studios, necessitate individual zones. There are as many as 12 heating zones in the larger buildings.

In the taller buildings are several floors of less than standard height which serve as pipe galleries for the horizontal steam and return mains. These spaces, situated between vertical zones, are also utilized extensively for ventilating fans and duct work. Wherever such a pipe gallery has been provided there is a small pressure reducing valve room close to the 50 lb riser. Here steam is reduced through ordinary reducing valves to 3 lb pressure. From here steam passes to heating control valves where it is further reduced to the required sub-atmospheric pressure for distribution through the horizontal mains in the pipe galleries and to the risers which serve the various groups of radiators. Some zones are upfeed and some are downfeed.

Vacuum Maintained

A vacuum as high as 25 in. of mercury may be maintained on the return system by means of an ejector type pump, one operating unit and a standby being sufficient for the smaller buildings, while the larger buildings have a four-unit installation. The centrifugal impeller is motor driven under the remote control of a switch sensitive to the pressures on both the supply and return radiator lines.

Impeller, exhauster nozzles and delivery tubes are mounted as a unit directly beside a tank, which serves the dual purpose of receiving the pump discharge and feeding the impeller. A constant level of water is maintained in the tank, through means of a float control, to give a static head sufficient to insure positive pressure feed to the impeller, thus eliminating suction leakage and priming difficulties.

Approximately 40 lb pressure is built up at the exhauster nozzles. The action, then, is as an ejector removing air, vapor and condensate from the return mains and discharging into the upper end of the tank. Air separates out and is vented away, while excess water runs off to the sewer.

The purpose of the vacuum pump is not to maintain a predetermined sub-atmospheric pressure in the return lines, but rather to maintain a differential pressure of about 2 in. of mercury between the radiator supply and return lines. This will give steam circulation at all times without the necessity of attaining a high vacuum in the return line unless the entire system is operating at nearly maximum vacuum. The pump motor is controlled by an on or off contact switch actuated by opposing bellows, one bellows connected directly to the radiator supply line and the other to the return. An adjustable differential spring maintains the desired balance of pressure between the two bellows, which in turn reflects the differential pressure in the system. When several zones are connected to a single vacuum pump each zone has a separate differential controller; the pump action then is governed in accordance with the requirements of the zone which is operating at the highest vacuum.

The heat output of all radiators may be varied both by steam temperature and quantity. For severe weather conditions, steam at 3 lb pressure (220 F) is available. For average winter conditions, radiators may be filled with steam at sub-atmospheric pressure, ranging down to 25 in. of mercury. These two extremes permit any radiator temperature between 220 and 133 F. In milder weather, lower heat output is obtained by partially filling the radiators with steam at the lower temperature. A proper balance in quantity of steam to each radiator in the zone is maintained (1) by the degree opening of the main control valve, and (2) by a proper pressure gradient throughout the supply lines. This condition is obtained by installing the correct orifice plate at each radiator inlet. The thermostatic controls of the main valve are inter-related to compensate for outside changes in temperature, or for sudden shocks in one section of a zone which would tend to throw the entire zone out of balance. Since one of the controls is directly related

to the heat output of a radiator it will be well to first describe the radiator details.

Radiation of Convection Type

The radiation is of the convection type, with copper tubes and fins, placed against the wall under the window casements, and enclosed in attractive housings to give the appearance of partially concealed radiation.

In the early installations the orifice plates were inserted directly behind inlet valves, and to service orifices it was necessary to remove the radiator enclosures and break the piping. This prompted development of a unique radiator valve in which an orifice opening is incorporated as an integral part. Even after installation the valve handle can be removed, giving an easy means of adjusting the orifice opening.

The size of the orifice determines the heat supply at the individual radiator, which may be regulated to meet any local demand. In addition, the proper selection of orifice size irons out friction losses throughout the system, resulting in a balanced pressure at all radiators. The steam traps placed at the return ends of radiators are so designed as to pass condensate and air, but close to steam, throughout the entire temperature range from 133 to 220 F. This is neatly accomplished by using a motive fluid to actuate the trap, the boiling point characteristics of which parallel the boiling point of water over the range from 25 in. of mercury to 3 lb pressure. A differential of 10 F gives the desired trap action.

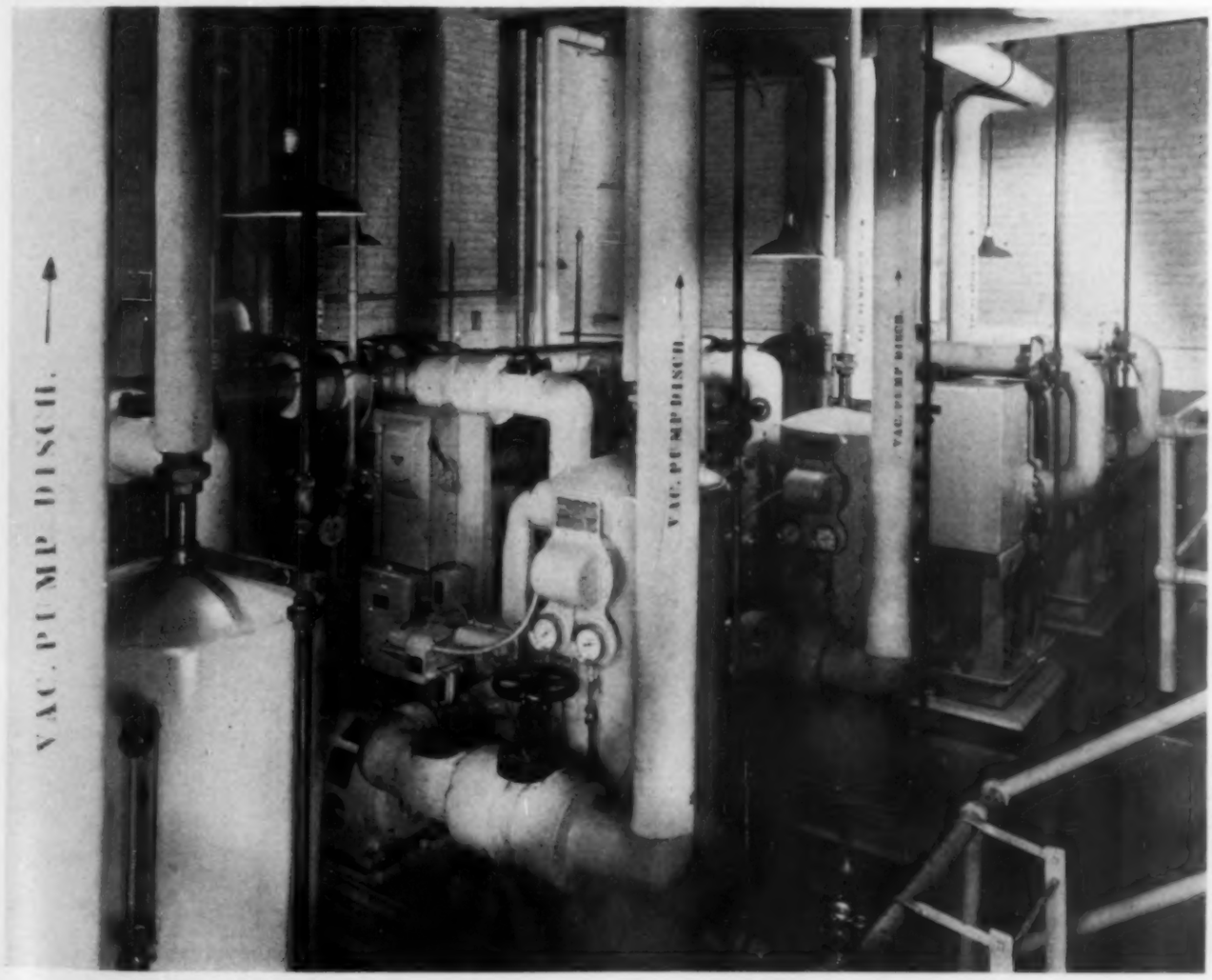
Three Controls Actuate Valve

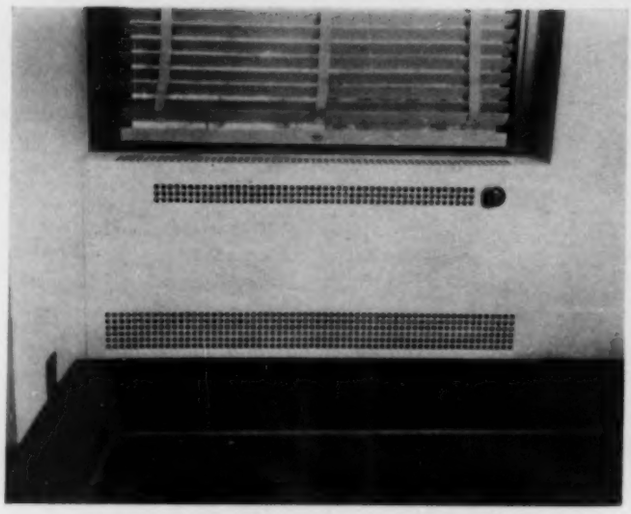
The main control valve for each zone is actuated by a combination of three distinct controls. These are the thermostats, heat balancers, and selectors. The thermostatic control comprises a group of four to nine thermostats connected in series and carefully situated throughout the particular zone so that they will be responsive to the average inside temperature conditions. The action of this control, then, is in accordance with the average temperature throughout the zone.

The heat balancer is merely a special type of thermostatic arrangement which measures the heat output of a typical radiator. This may be used as a complete control in itself or may be used in conjunction with the other control apparatus. The heat selector is a thermostatic arrangement placed against the inside face of a window in the zone; its action is dependent upon the rate of heat loss through glass.

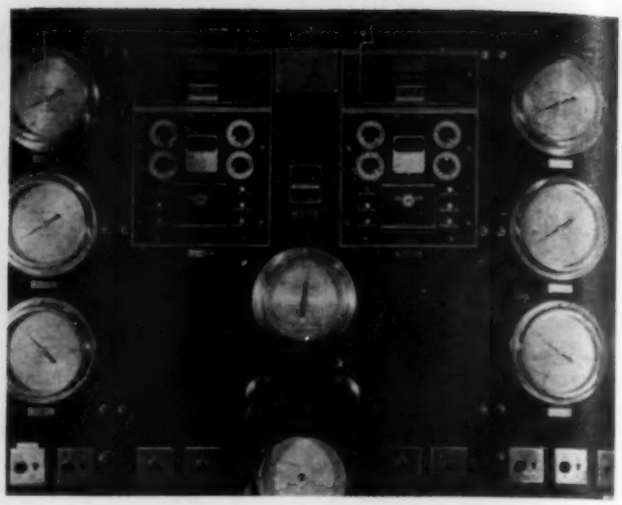
Older types of selectors in use in some of the buildings are manually operated resistors. In the newer

Heating system vacuum pumps in the International building





Radiation is of the convection type, placed against the wall under the window casements



A portion of the heating system control panel in the Associated Press building

buildings, where the latest equipment is used, all of the thermostats are simply suitable forms of resistance thermometers with no moving parts whatever. They are all connected into an electrical wheatstone bridge circuit; the galvanometer in the circuit actuates the control valve. In the older buildings the more usual types of thermostatic arrangements are used which have moving elements operating on slide wire resistors.

The newer type provides a means of readily raising or lowering temperatures generally without necessitating the resetting of a number of thermostats situated in tenant space—a means of controlling the steam usage automatically, semi-automatically, or manually. From the control panel the following observations may also be made: percentage of valve opening, average temperature of zone, and an indication of the heat output of a typical radiator.

In tall structures during the heating season, air normally leaks inward at the lower floors, finds its way to elevator shafts, and then leaks outward through windows and openings in upper floors. This action is distorted and varied in many ways by the effect of wind and sun. Various steps have been taken to reduce the effect of this chimney action with its accompanying losses of heat. These include the use of revolving doors on main floors, the use of automatic doors at loading platforms, and in some cases the providing of doors at elevator corridors.

Operation of System

It is the practice at Rockefeller Center to maintain a minimum temperature of 73 F during hours of regular occupancy and at night to lower the temperature to 65 F. The temperature of 65 F for night service was established in view of several considerations, as reasonable comfort for the cleaners who do their work at night, assurance of proper control and comfort in the morning, and in the case of tenants who wish to work at night, those who are not comfortable at 65 F can gain a few more degrees by the use of simple electric heaters.

Tenants are advised that under normal conditions the leakage of air around metal window sashes is sufficient for usual ventilating requirements; a window raised just enough to break the seal at the sill and at the meeting rails will increase this leakage materially and under these conditions comfort may generally be obtained. Those who persist in a more extreme window opening may expect the temperature to fall below 73 F.

How Manager Keeps Track of Building Temperatures

The building manager of a 19 story metropolitan office building has two lights installed near the steam pressure gages in his 11th floor office. These lights are turned on or off by thermostats in an office on another floor which was found to be representative (from the heating standpoint) of a large part of the building. If one of the two lights is on, it indicates that the temperature in the representative office is below 71 F; if the other light is on it means that the temperature in the representative office is 75 F or over. Thus the building manager has before him a constant approximate indication of representative building temperature during the day.

A similar light arrangement is installed in the boiler room for the guidance of the operating engineers. In this case, the lights are turned on or off by a thermostat in the tower part of the building. When the "high light" turns on, it indicates that temperatures in the tower space are satisfactory and therefore they are probably satisfactory over the entire building. The boiler room indicators are particularly useful in connection with warming up the building in the morning to assure satisfactory temperatures for the occupancy.

How Manager Keeps Track of Building Temperatures

The manager of an office building has two lights in his office controlled thermostatically from a representative location on another floor. If one is on, it shows the temperature in the representative location is 75 F or over and the other shows that it is 71 F or under. A similar light arrangement in the boiler room is controlled by a thermostat in a tower office space. This is of aid to the operators, particularly in warming up the building

Power Piping Drafting Today Requires Skill and Knowledge

By Albert Jorgensen*

SINCE the scope of power piping drafting is wide and space is limited, our purpose here is to discuss the subject in a general way and to indicate to the reader where he may turn for more detailed information concerning its various phases.

Recent advances in the science of metallurgy, in the knowledge of the properties of metals at elevated temperatures, and in the art of welding have made possible many improvements in the design of power plants with the result that the temperatures and pressures used are much higher than formerly. Furthermore, auxiliary equipment introduced in the interest of fuel economy is used more extensively than in the past. The net result of these advances—all things considered—has been to complicate further the problems of the piping designer and draftsman. Moreover, plants are becoming larger, a fact which adds to the problem of adequately representing the piping on drawings of convenient size.

In the field of piping as in other fields of engineering endeavor, advances in designs and refinements in manufacturing and fabricating processes have made imperative a greater degree of control through the media of drawings and specifications. The practice of making drawings incompletely dimensioned and of a sketchy nature, leaving much to the judgment and discretion of mechanics, cannot be followed where important work is being done. The necessity for and the economy of good drawings has become recognized. A few dollars spent in the drafting room may save many dollars in expediting the work and in preventing waste of material.

The functions of a piping draftsman are twofold, embracing both skill and knowledge. The appearance and utility of a drawing depend upon the draftsman's skill in executing line work and lettering in pencil or ink, on paper or cloth, as the case may be. Pencil drawings on pencil cloth are now being used extensively. Considerable skill in technical sketching is desirable inasmuch as engineers and draftsmen frequently "talk with a pencil." These skills are developed to some extent in the drawing courses offered in schools and colleges. The draftsman, however, must refine his technique and develop his speed through experience before he can compete successfully as a full-fledged draftsman in a commercial drafting room.

Sources of Piping Information

The knowledge which a good piping draftsman should possess may be divided into two classes: (1) that which deals with the drafting problem of graphically representing a piping system; (2) that knowledge which is engineering in character and necessary in his work. The latter includes a knowledge of the fundamental engineering principles involved in piping design, a practical knowledge of the construction and operation of mechanical equipment, and familiarity with the standards, specifications, and codes which apply to power piping.

For fundamental knowledge of the type included in (1), the reader is referred to any good text on drawing (such as Engineering Drawing, by Jordan and Hoelscher, third edition, published by John Wiley & Sons, New York). Most of the material in such a book is related in some way to the problems of piping drafting, but the chapters which apply most directly are those on orthographic projection, isometric projection, oblique projection, fasteners, machine drawing, architectural drawing, structural drawing, piping drawing and sketching.

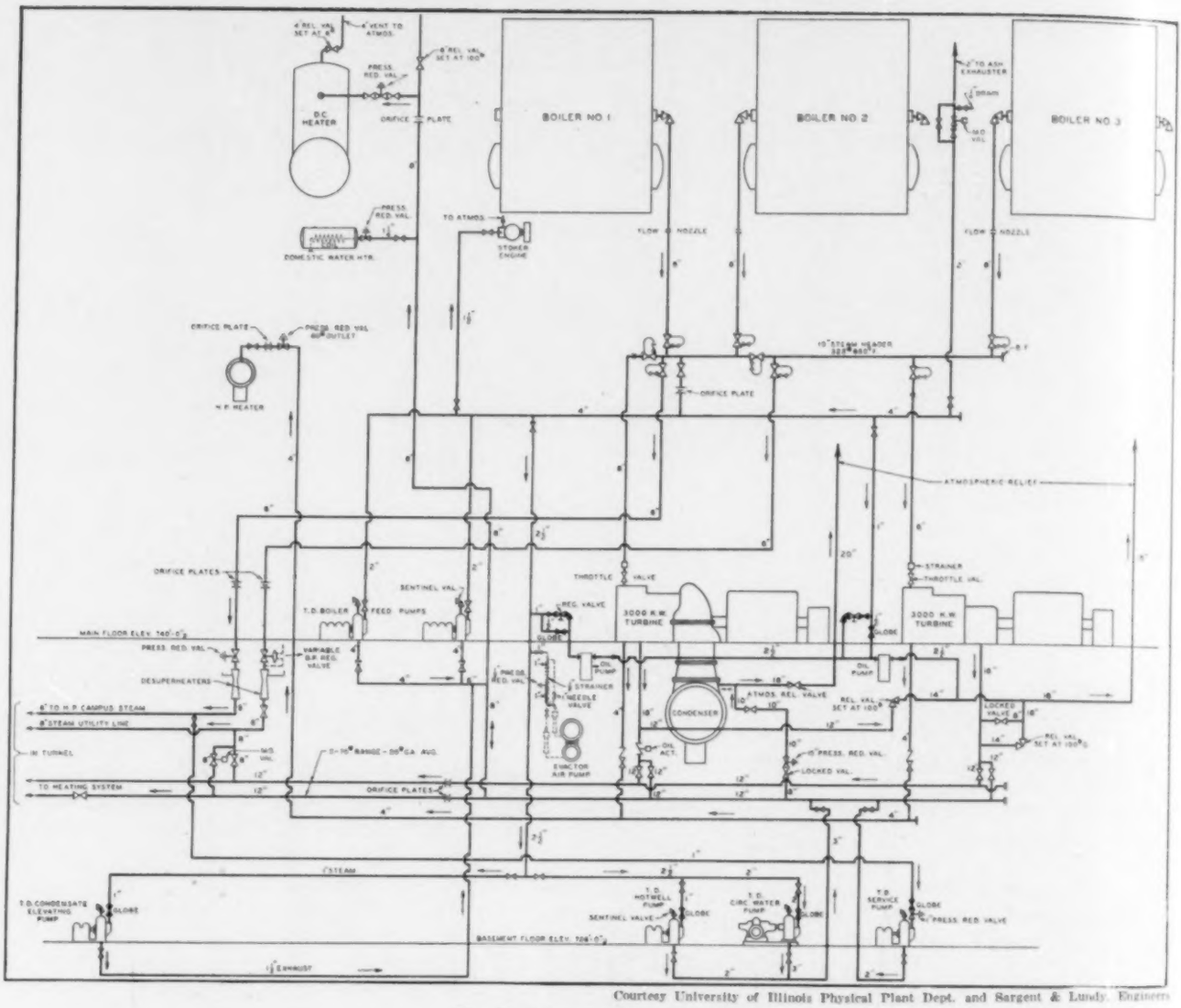
ASA Standard Z14.2—1935, Drawings and Drafting Room Practice—Graphical Symbols, contains some symbols which are applicable in power piping drafting.

*Assistant Professor, General Engineering Drawing, University of Illinois.

Power Piping Drafting Today Requires Skill and Knowledge

By Albert Jorgensen

Recent advances in the sciences and arts involved in power piping design and installation complicate the problem of the piping designer and draftsman, have made imperative a greater degree of control through the media of drawings and specifications. The functions of the piping draftsman are twofold, embracing both skill and knowledge; the purpose here is to review the subject in a general way and indicate to the reader where he may turn for more detailed information on various of its phases. . . . Sources of such information include texts such as Engineering Drawing, by Jordan and Hoelscher; the Piping Handbook, by Walker and Crocker; standards and codes of such organizations as the American Standards Association, the American Society of Mechanical Engineers, the American Society for Testing Materials, the American Petroleum Institute, the Manufacturers Standardization Society of the Valve and Fittings Industry, etc. Many articles dealing with power piping are published in HEATING, PIPING AND AIR CONDITIONING and in other technical magazines and journals. . . . Steps in the power piping design procedure are (1) the engineering survey and reports, (2) selection of major items of equipment, (3) lay out of the plant. The drawings which facilitate the fabrication and installation of the piping include the plot plan (the scale being on the order of 1 in. equals 20 ft to 1 in. equals 100 ft), general building plans (scale about ⅛ in. equals 1 ft), piping or flow diagrams, piping assembly drawings, details of pipe supports, and shop drawings. Examples of a steam piping diagram, the flow diagrams of a power plant addition, and an example of the application of isometric drawing to piping diagrams are reproduced



Courtesy University of Illinois Physical Plant Dept. and Sargent & Lundy, Engineers

Fig. 1—A steam piping diagram

The American Standards Association is now preparing a standard on Graphical Symbols and Abbreviations for Use on Drawings.

The catalogs of some manufacturers of pipe, valves, and fittings, and the catalogs of some piping fabricators, contain suggestions for the preparation of drawings and specifications. These catalogs also contain other useful information, including design suggestions, and the important dimensions of standard products.

An item in the draftsman's mental equipment which cannot be over-emphasized is the ability to visualize. In working on any particular piping system, the earlier he acquires a mental picture of the various lines in the system and their relations to each other and to the building and the equipment, the better he can function.

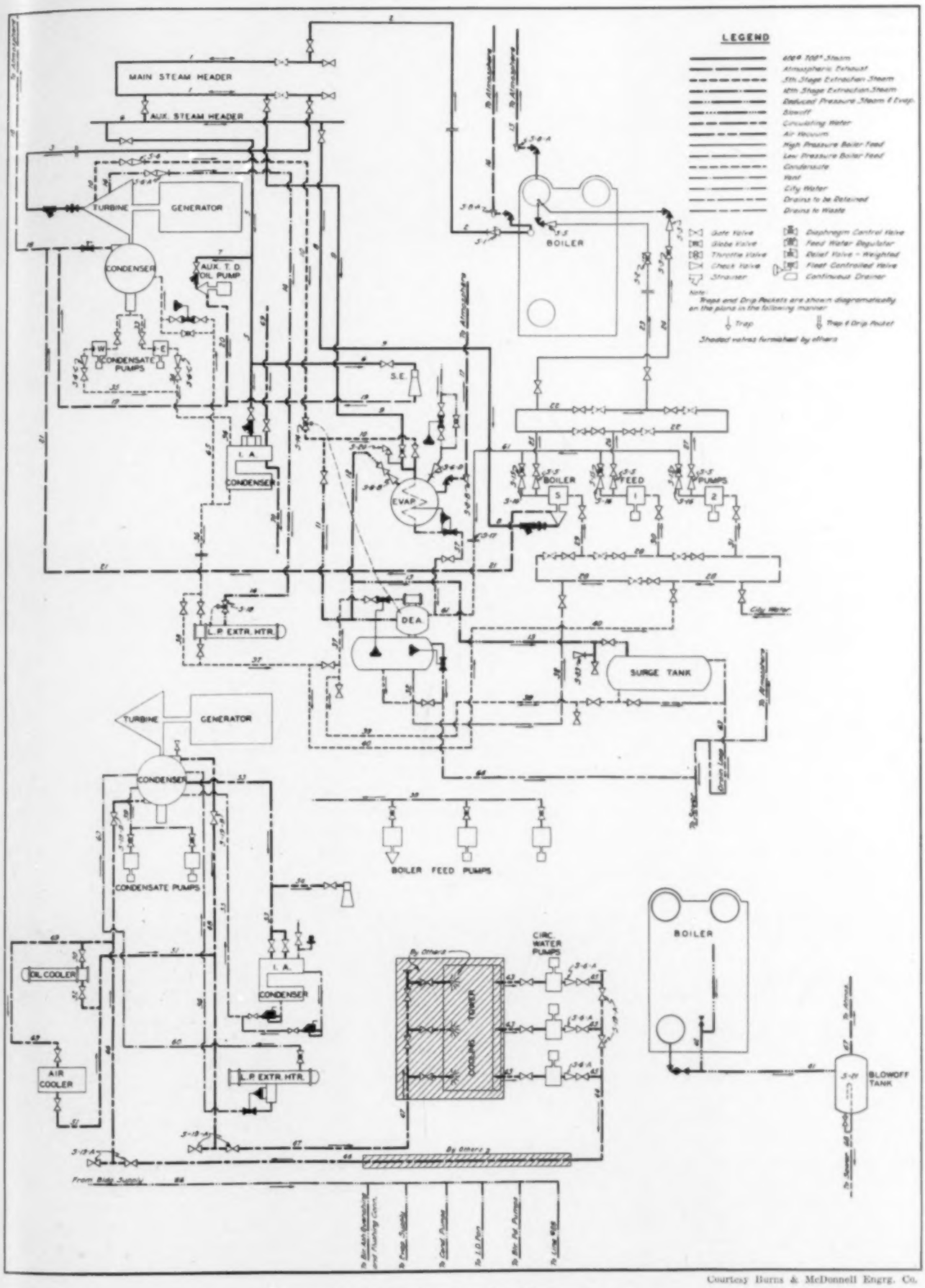
Concerning the knowledge included in (2)—that of an engineering character—the more a draftsman knows of the design and functions of the equipment and the connecting piping, and the problems involved in its manufacture and installation, the more valuable he will be to his employer.

Much of the design of power piping is controlled by code. The American Society of Mechanical Engineers Code for Power Boilers (which is followed by most state codes) covers in addition to other things the piping, valves, and fittings which are attached directly to the boiler. The Code for Pressure Piping[1] covers the remainder of power plant piping (excepting the plumbing and other minor piping systems). Sections 1, 5, and 6 of this code cover power piping systems, fabrication details, and materials, respectively. This code is undergoing a complete revision and probably will be available in the revised form some time this year.

The codes mentioned refer to numerous standards and specifications of the American Standards Association, the American Society for Testing Materials, the American Petroleum Institute, the Manufacturers Standardization Society of the Valve and Fittings Industry, and other organizations. Copies of these standards and specifications may be obtained from the organizations.

Probably the most valuable single volume which the prospective piping designer or draftsman may have at hand is the Piping Handbook, by Walker and Crocker, third edition, 1939, published by the McGraw-Hill Book Co., New York. In this book, the nature and functions

[1]The Code for Pressure Piping was reviewed in detail in a series of articles by Sabin Crocker published in HEATING, PIPING AND AIR CONDITIONING, January-August, 1934.



Courtesy Burns & McDonnell Engrg. Co.

Fig. 2—Power piping flow diagrams

of the various types of pipe, valves, fittings, and other related appurtenances, are discussed. In addition, the problems of design of piping systems are treated. Chapter VIII, Power Plant Piping, is of particular interest.

Many articles dealing with power piping are published in HEATING, PIPING AND AIR CONDITIONING and in other technical magazines and journals. These articles may be found readily by referring to the Engineering Index and the Industrial Arts Index.

Procedure in Piping Design

Since the conditions under which power plants are designed and built vary considerably, engineering procedures must necessarily vary. Procedures differ, for the most part, in the degree to which plans and specifications must be prepared for open bidding as a requirement of law, as in the case of many public institutions, or as a matter of policy in the case of private companies. The first step, in any instance, is to make an engineering survey of the present and future needs for power, and also to outline a course of procedure which will result in supplying the needs. The final recommendation may entail the modernization or extension of an existing plant, or the building of a new plant to augment or replace existing facilities.

The engineering reports in which this material is presented are quite elaborate and contain facts and figures to support the findings and justify the recommendations. Since the cost of the new construction and the economy of its operation must be estimated, the proposed design must be outlined. The numbers and capacities of the major units (boilers and turbo-generators) are presented, and the auxiliary equipment is indicated. Heat balance studies which show the exchange and flow of heat under different conditions of operation are given. The performance characteristics of obtainable equipment must, of course, be known before making heat balance studies. While these investigations usually are carried on by engineers not connected with the drafting room, draftsmen may be called upon to draw the statistical charts and heat balance diagrams embodied in the reports.

The second step is to select the major items of equipment and as many of the minor items as possible and obtain certified drawings of the equipment from the manufacturers. These drawings should show the important dimensions and also the terminal connections to which the piping is to be attached.

The next step is to lay out the plant, deciding tentatively, at least, how the equipment is to be arranged and also deciding the principal features of the building such as column and beam spacing, floor elevations, and wall locations. The final details of the building and the arrangement of the equipment are determined as the piping layout progresses. In many instances, however, the construction of the building may be well advanced before the piping plans are completed.

One of the first things that is done in this rather complicated process is to design the various lines in the piping system to the extent of determining what pipes are needed and their sizes. The placing of valves also is decided. Taking cognizance of the fact that some of the units in the plant may be out of service at times for various reasons, the piping system should be designed to give the desired operating flexibility. The designs at this stage are recorded in part on piping diagrams. Other features of the design, such as the pressures and temperatures to be encountered, the materials to be used in the pipe, valves, fittings and gaskets, the types of joints to be used, and the kind and thickness of insulation are listed, and later they are shown on drawings or in specifications.

At this stage the detailed layout of the piping is begun. The chief considerations at this point are stresses in the piping, forces imposed on the equipment, provisions for expansion (particularly in the high temperature lines), pipe supports, accessibility for repairing the piping system and the equipment, convenience of operation, and appearance.

The drawings are in the form of assemblies. The larger and more important lines are laid out first. The minor lines are then fitted into the remaining space. Problems arising in the layout of the minor lines may in some instances be solved satisfactorily only after revisions in the major lines have been made.

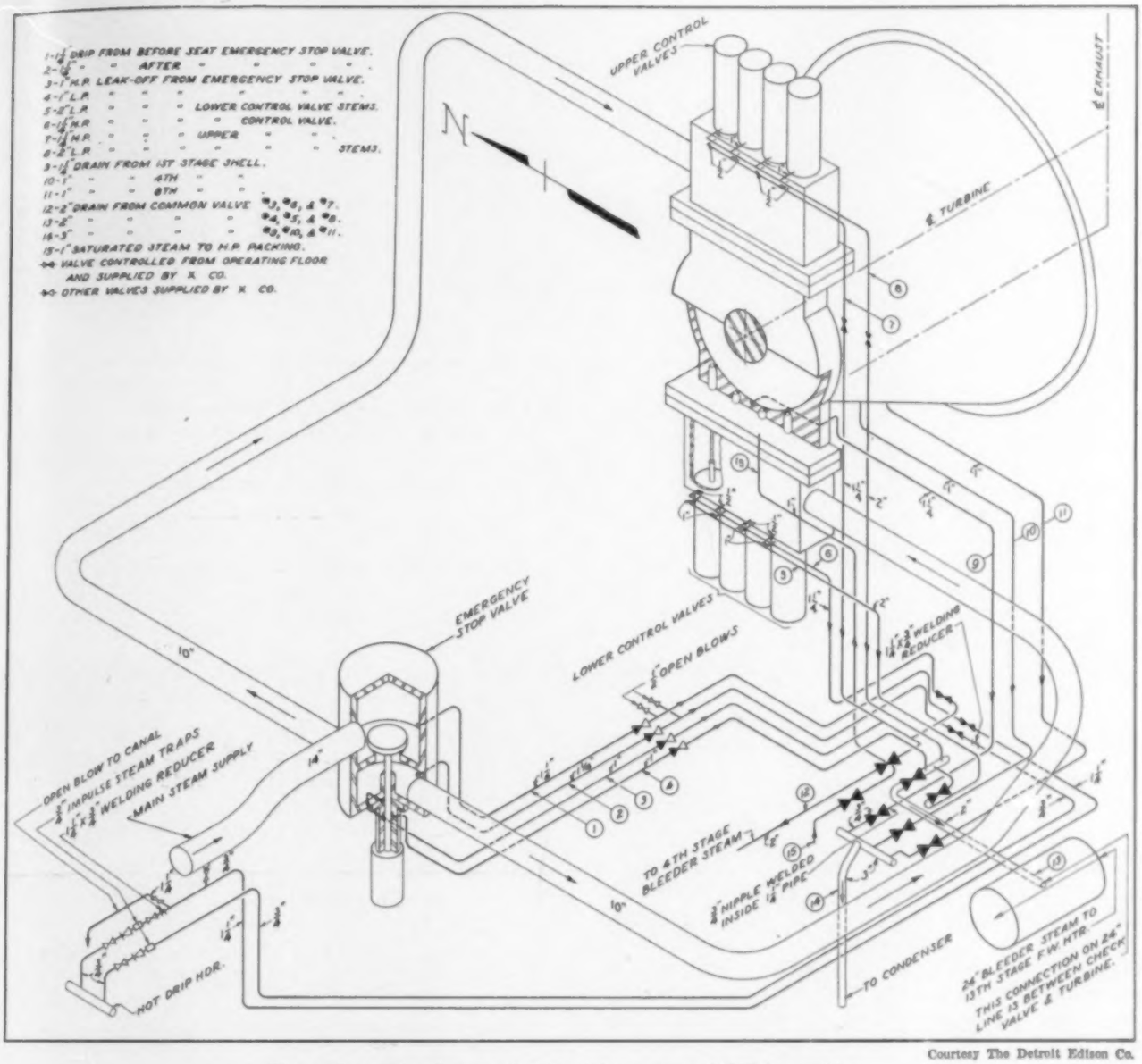
After the piping contract is let, the piping contractor is required to submit for approval detailed shop drawings of the piping he is to install. These drawings are usually made in the drafting room of the fabricating company that is to supply and fabricate the piping. He is also required to furnish drawings showing the important dimensions of and the pipe connections on equipment, such as pumps, feedwater heaters, tanks, and other items which may be included in his contract.

As stated previously, the conditions under which power plants are designed and built vary, with the effect that engineering procedures and the resulting drawings and specifications differ. Under one set of conditions we find a power plant being designed by consulting engineers who must prepare plans and specifications which permit open bidding on all phases of the work. At the other extreme, an organization may have its engineers to design the plant, select the equipment, and supervise the erection—all of which is accomplished by the company's own crews. Any condition between these two extremes may exist.

Furthermore, if there is a piping contract, the character of the plans and specifications will depend on the scope of the contract, which may or may not include furnishing and installing things not closely related to the power piping system proper. Such things as electrical work and the plumbing and heating systems of the power plant building are omitted in this discussion.

The furnishing and installing of gage boards, meters, instruments, steam and water sampling devices and their connections may be included in the piping contract. Suffice it to say that, in this case, drawings and specifications are supplied to insure the desired results. The locations of orifice plates and venturi meters are shown usually on the piping drawings supplied by the designers, and the tubing which connects these to the gages and recording devices may be shown on drawings supplied by the contractor. In most instances the tubing is laid out in the field by the construction organization.

It is possible for the engineer to exercise complete dimensional and material control through the media of drawings and specifications. The extent to which he does this by means of his design drawings and specifications depends largely upon the amount of time and


1-1/4" DRIP FROM BEFORE SEAT EMERGENCY STOP VALVE.
2-1/2" " " AFTER " " " " " .
3-1" H.P. LEAK-OFF FROM EMERGENCY STOP VALVE.
4-1" L.P. " " " " " " .
5-2" L.P. " " " LOWER CONTROL VALVE STEMS.
6-1/2" H.P. " " " " CONTROL VALVE.
7-1/4" H.P. " " " UPPER " " " .
8-2" L.P. " " " " " " STEMS.
9-1/2" DRAIN FROM 1ST STAGE SHELL.
10-1" " " 4TH " " " .
11-1" " " 8TH " " " .
12-2" DRAIN FROM COMMON VALVE #3, #6, & #7.
13-2" " " " " #4, #5, & #8.
14-3" " " " " #9, #10, & #11.
15-1" SATURATED STEAM TO H.P. PACKING.
VALVE CONTROLLED FROM OPERATING FLOOR AND SUPPLIED BY X CO.
OTHER VALVES SUPPLIED BY X CO.
UPPER CONTROL VALVES
EXHAUST
TURBINE
EMERGENCY STOP VALVE
LOWER CONTROL VALVES
OPEN BLOWS
1/2" x 3/4" WELDING REDUCER
OPEN BLOW TO CANAL
3/4" IMPULSE STEAM TRAPS
1-1/4" x 3/4" WELDING REDUCER
MAIN STEAM SUPPLY
TO 4TH STAGE BLEEDER STEAM
3/4" NIPPLE WELDED INSIDE 1-1/4" PIPE
TO CONDENSER
24" BLEEDER STEAM TO 13TH STAGE F.W. HTR. THIS CONNECTION ON 24" LINE IS BETWEEN CHECK VALVE & TURBINE.
HOT DRIP HDR.
10"
14"

Courtesy The Detroit Edison Co.

Fig. 3—Isometric diagram of drip piping around 75,000 kw turbine

money at his disposal and his preference in the matter. Power piping contracts usually contain a statement to the effect that the piping contractor is to furnish and erect a complete and operative piping system regardless of errors of omission or commission in the plans and specifications. Such statements should be considered as protections against inadvertent errors and not taken as excuses for careless work in the drafting room.

Types of Drawings

The drawings which are most universally furnished to facilitate the fabrication and installation of a power piping system are the plot plan, general building plans, piping diagrams, piping assembly drawings, details of pipe supports, and shop drawings. In addition, equipment manufacturers are required to furnish drawings showing the important dimensions of and the pipe connections on the items which they are to furnish. The primary purpose of manufacturers' equipment drawings is to make possible a detailed layout of the piping system.

Plot Plan—The function of the plot plan is to locate the site of the plant geographically and to show the relation of the plant to the site and the relation of the site to transportation facilities. Scales of the order of $1'' = 20'$ to $1'' = 100'$ are used.

General Building Plans—General plans and elevations (scale about $\frac{1}{8}'' = 1'\text{-}0''$) which show the principal dimensions and features of the building with the major power equipment items in place are furnished to provide an over-all conception of the plant. Enough of the structural features are given so that the larger scale assembly drawings, on which only a part of the plant shows on any one drawing, may be correlated by means of columns and floors which carry similar designations on the general plans and on the detailed piping assemblies.

Piping Diagrams—Piping diagrams (frequently designated as flow diagrams) are included in a set of piping

plans to show the direction of flow in the various lines, and to serve as aids in interpreting the piping assembly drawings. The characteristics of these diagrams may be observed by referring to Figs. 1, 2 and 3. It should be noted that they are diagrammatic in that they are not drawn to scale. The symbols used are characteristic of the shape of the items represented.

Fig. 1 shows a steam piping diagram which was accompanied by three other piping diagrams in the set of piping plans of which it was a part. Because of the reduced scale at which this diagram is shown here, several of the minor features of the original diagram are omitted. The other three piping diagrams showed boiler feed and condensate piping, service and circulating water piping, and vents, drains and turbine oil piping, respectively. In the office in which Fig. 1 was originally prepared, the piping diagrams are drawn to show approximately the relative positions which the major equipment items are to occupy in the plant. It may be noted that the turbo-generators and the pumps are shown as elevations and the boilers are represented as plan views on this particular diagram.

Fig. 2 shows completely the flow diagrams of a power plant addition. On these diagrams the various lines are designated by numbers. These numbers serve to identify the lines on the assembly drawings.

An example of the application of isometric drawing to piping diagrams is shown in Fig. 3.

[This discussion of power piping drafting is to be continued in a second article.]

Will a Wood Joist Near a Steam Pipe Catch Fire?

A reader of HPAC writes that he attended a fire prevention meeting where it was stated that a large fire was caused by ignition of a wood joist through which a pipe carrying 5 lb steam passed. As he could not visualize how steam at the corresponding temperature for this pressure could ignite the wood joist, he asks for some information on the subject. The following comment on the matter has been prepared by John A. Neale, Engineer, Protection Dept., Underwriters' Laboratories, Inc.

The temperature at which wood will ignite depends upon a number of things. Of these variables, the most important are the kind of wood, the condition, and the length of time that heat is applied. Tests have shown that the more commonly used kinds of wood will ignite rapidly when exposed to temperatures of 750 F and fairly promptly at temperatures around 400 F. It is also known that long, continued exposure to lower temperatures will result in ignition and there are numerous instances of record in which ignition has been caused by low pressure steam pipes.

It is generally considered that heating appliances should be so designed and installed that adjacent woodwork will not reach temperatures higher than 90 F above room temperature (approximately 160 F). It is felt that this limit incorporates a reasonable factor of safety.

Safe practice indicates that a clearance be provided between steam or hot water pipes and woodwork, and many building codes require this protection.

The building code recommended by the National Board of Fire Underwriters treats this item as follows in Section 1210, Paragraph 1 (a):

"Where steam or hot water heating pipes pass through combustible floors or partitions or other combustible constructions, there shall be an open space of not less than 1 in. on all sides of the pipe which shall be capped at the ends with incombustible material."

Will a Wood Joist Near a Steam Pipe Catch Fire?
(Answer to a Reader's Question)

A reader of HPAC asks for information on the ignition temperature of wood, in connection with low pressure steam pipes passing through wood joists. According to John A. Neale of Underwriters' Laboratories, Inc., who has prepared this reply, the temperature at which wood will ignite depends upon a number of things, and long continued exposures to the lower temperatures will result in ignition. . . . It is generally considered that heat appliances should be designed and installed so that adjacent woodwork will not reach temperatures higher than 90 F above room temperature (approximately 160 F). Safe practice indicates clearance between steam or hot water pipes and woodwork, and many building codes require this, including the National Board of Fire Underwriters'

Cost of Operating Air Conditioning System

By J. A. Gazelle*

An average of 5870 kwhr per mo of electricity was the amount of power needed to operate the 24 hp air conditioning system at the Alabama Power Co. offices in Mobile, Ala., in 1939, according to figures released by the company. Power consumption in 1938 averaged 5958 kwhr per mo. The difference in the average monthly power consumption in 1938 and 1939 was caused by the higher temperatures in 1938. While electrical power figures are available only for 1938 and 1939, maintenance and water data were recorded over a 5 yr period from 1935 through November, 1939. Cost of water used in the system averaged $10.38 per mo over the 4 yr, 10 mo period. On the basis of 8093 sq ft of conditioned space, the total cost of water and all charges for sewer expense was 2c per sq ft per year.

Exclusive of water and power costs, the average cost of maintaining the system was 2c per sq ft of floor area per yr for the cooling seasons of 1936, 1937, 1938 and 1939. This figure covers the expense of painting, belts, refrigerant, washing and renewing filters, greasing motors and fans, etc.

The air conditioning system consists of one duplex condensing unit, two industrial conditioning units, and one comfort conditioning unit. Conditioned space consists of general sales area, filing department and one private office on the first floor and 12 offices on the second floor.

*Carrier Corp.

Cost of Operating Air Conditioning System
By J. A. Gazelle

An average of 5870 kwhr of electricity per month was required in 1939 for the 24 hp air conditioning system at the Alabama Power Co.'s offices in Mobile. The figure for 1938, when temperatures were higher, was 5958 kwhr. Cost of water averaged $10.38 per month over a 5 yr period, total cost for water and sewer expense being 2c per sq ft of floor space per yr. Maintenance cost was also 2c per sq ft per yr, and covered painting, belts, refrigerant, washing and renewing filters, and lubrication

By Samuel Martin, Jr.*

NEARING completion on a 51 acre tract in the San Fernando valley near Burbank, Calif., is the completely air conditioned motion picture studio city of Walt Disney Productions, creators of Pinocchio, Jiminy Cricket, Mickey Mouse, Donald Duck and other world famous characters. It represents a solution to one of the most complex air conditioning problems ever posed.

First of all, Disney demanded the utmost provision for the health and comfort of his hundreds of employees, despite the complications created by the need of unusually stringent control of sound, air movement, temperature, humidity and cleanliness. In the great animation building alone some 900 creative artists are employed at exacting tasks, in rooms having varying exposures, occupancies, and internal loads. In the camera building, the theme song was "Keep it clean!" for every particle of dust may be harmful to a finished picture. Tremendous heat loads from banked studio lights had to be disposed of without the creation of drafts. There were orchestra and dialogue stages where air requirements had to be adjusted to one person or to 100 with equal facility. Outside air intakes had to be guarded against bringing in the zooming of airplane motors from the nearby Union air terminal. These were only a few of the problems involved.

Although the formal opening of the new studios was not scheduled until this month, parts of the new studio facilities were used in the creation of "Pinocchio," Disney's newest full-length feature now being released throughout the United States.

600 Hp Refrigeration Plant

Basically of the central plant type, the air conditioning system operates with hot or cold water to produce specified temperatures. A natural supply of 67 F underground water on cold days preheats the entering air, and on hot days precools it, thereby reducing materially the overall operating cost. Including the effect of both the natural water supply and the refrigeration equipment, the total tonnage of the job is more than 1400 with approximately 1300 motor hp used in the operation of the various blowers, water circulating pumps and refrigerating machines. A 600 hp multiple condensing unit plant, designed for high efficiency at full or very light load, supplies refrigerated water for summer air conditioning all buildings on the central plant lines.

In the winter most of the buildings are heated by air conditioners receiving their heat from two central 190 hp boilers. Only the smaller, isolated buildings have independent air conditioning arrangements—all others utilize heated or cooled water from the central source.

Using the heating or cooling effect of the water supplied by the central plant, individual air conditioners serve each building. They condition the air at a single point—or at several load centers—in each building and in most cases are situated in the basement. From the conditioners the air is conveyed to the various rooms through ducts. In the winter the air is heated to the proper temperature, humidified and carefully cleaned. It is kept in constant motion and outside air is supplied in the proper proportion (in most cases 100 per cent outside air is used, with no room air recirculated back into the rooms). In summer the same system supplies cooled, dehumidified air.

Animation Building Is Largest

The largest building on the grounds, arranged to accommodate some 900 creative artists who "animate" the characters in Walt Disney Productions, is the animation building. This structure has a total floor space of 150,000 sq ft and is composed of eight wings extending four on each side from a central tier. Altogether there are more than 300 individual offices here.

Each of the eight wings is conditioned by its individual air conditioner unit. Air is exhausted from rooms through continuous special baseboard grilles also embodying open face conduits for light, telephone and signal wiring, as well as compressed air lines for the artists' air brushes. The "used" air is expelled to the outdoors.

*Contractor Sales Manager, Air Conditioning and Commercial Refrigeration Dept., General Electric Co.

In the animation building no room air is recirculated; only outside air is delivered through the conditioners, and is brought to the conditioners from a level far above the ground. Then it is passed through filters and next comes to the well water coils which, being at approximately 67 F, preheat in winter and precool in summer. Following this step, the air is treated by vapor jet humidifiers. Next the incoming air is divided—part is diverted through hot water coils into a hot plenum, and part is routed through refrigerated water coils into a cold plenum.

By making available sources of cool and warm air, and using proportioning dampers for individual take-offs, the engineers have assured that air delivered to each zone will always be a properly blended mixture of warm and cool conditioned air from these two plenum sources—the exact proportion of the mixture is determined by thermostats, and in each room a constant air flow is maintained. Since there are 156 independent thermostatic control stations in the animation building, and conditions must be maintained closely throughout, the mixture of warming and cooling elements must be very accurately regulated.

Each wing contains many rooms having different exposures, occupancies and internal loads. Projection rooms, musicians' rooms, artists' studios, and private offices are grouped on a single conditioning system. However, separate controls, arranged to operate mixing dampers on individual supply ducts, will provide suitable conditions in each group of similar rooms, even under conditions of quick and extreme load change.

Walt Disney Air Conditions

By Samuel Martin, Jr.

Air conditioning for the new motion picture studios of Walt Disney Productions near Burbank, Calif., presented several complex problems because of the necessity of stringent control of sound, air movement, temperature, humidity and cleanliness. In the animation building some 900 creative artists are employed at exacting tasks, and require conditions which will promote their health and comfort. In the camera building, cleanliness is paramount, for every particle of dust may be harmful to a finished picture; tremendous heat loads from bank studio lights must be taken care of without creation of drafts. On orchestra and dialogue stages, air requirements for one or 100 persons must be suplied. Outside air intakes had to be equipped with sound traps to prevent bringing in noise from a nearby airport. . . . The air conditioning system is basically of the central plant type, cold or hot water being furnished to various conditioning units. Underground water at a temperature of 67 F is used for precooling in summer or preheating in winter. A 600 hp multiple condensing unit refrigeration plant supplements the cooling effect of the natural water supply, the total tonnage of the system being approximately 1400. In winter most of the buildings are heated by air conditioners receiving their heat from two central 190 hp boilers. . . . In the celluloid storage vaults all paintings on celluloid are kept at even temperatures and humidities to guard against shrinkage which would disturb the all-important register of the sequence drawings; correct air conditions also protect against deterioration

To assure adequate delivery of outside air, these systems are supplied with exhaust as well as supply fans, so that air supply is not dependent on the variable of building air leakage.

Following treatment in the central conditioners situated in each of the wings, the air is ready for delivery to the individual rooms through special air and lighting fixtures. These fixtures, of special design to give better light to artists in the animation building, at the same time deliver an even film of the conditioned air across the ceiling. Thence the air moves slowly and without draft through the room to the baseboard exhaust.

On the roof of the animation building is the Animator's Club, complete with gymnasium, massage room and lounge. This is served by a separate air conditioner.

Cleanliness Paramount in Camera Building

Cleanliness is of particular importance in the camera building, for a single particle of lint or dust on a painting might, in being photographed, produce light effects that would be harmful to the finished picture. To guard against such an occurrence, the camera rooms are kept scrupulously clean, floors are carefully waxed, and the operators even wear special "lintless" clothing. The only entrance to the camera rooms is through a "dedusting" chamber where any loose particles on the clothing of operators are blown off by high velocity air jets and drawn down through a grating in the floor. From there, on its way outdoors, the same air is routed to cool the motor-generator sets which supply electricity to the cameras.

In the camera rooms, the problem of heat disposal without drafts was encountered, since some of the single cameras use more than 70 kw of energy. Where possible, exhaust hoods are used to draw off air at the points of heat concentration, and multi-outlet air distribution permits the delivery of the required cooling effect without drafts. In this instance the same air is used for three purposes: first, for some of the general air conditioning in the camera building; second, "dedusting"; and third, cooling the motor-generator set room.

In the camera rooms, where a major portion of "Pinocchio" was shot, the air conditioning filters cleanse the air so completely that white, fine mesh cloth mats placed directly before the air delivery grilles for five hours show no sign of lint or dirt. In the cutting building, by similar methods, these super-clean conditions are reproduced.

The Big Stages

The orchestra stage is built with a special acoustic shell backing up the orchestra in order to provide maximum brilliance of sound without echo or distortion. Since at some times large groups of musicians may be on this stage for recordings, while at other times there may be only a single performer, controllable as well as even air distribution is needed. To permit this, the entire space above the top of the acoustic shell is built air tight, and the air conditioning system fills the air tight space with air under slight pressure. Released to the stage through a series of slots behind the convolutions in the shell, the air is exhausted evenly through grilles situated in each platform riser, below.

Fig. 1—Walt Disney, William Garity and Elliott Harrington inspect one of the blower fans which form part of the air conditioning system for the new Disney studios. . . . Fig. 2—Mr. Harrington explains one of the combination lighting and air distribution fixtures to Mr. Disney. . . . Fig. 3—Large sound stage at the Disney studios; air is delivered to stage area through slots between convolutions of walls and ceiling. Return grilles may be seen under the platform risers. . . . Fig. 4—Mr. Garity shows Mr. Disney an air conditioning control panel

Another large stage in the studios is the dialogue stage. Here, as in the case of the orchestra stage, special precautions were taken to prevent noises which would interfere with satisfactory recordings. The nearness of the air terminal at Burbank necessitated careful sound baffling of the large outside air intakes to eliminate the roar of transport planes which sometimes climb directly over the studio location. Carefully selected blowers, low air velocities, acoustically treated ducts and sound traps are among the preventive measures taken

Weather Studies Made

An example of the care with which the air conditioning system was designed is found in the weather studies made preliminary to installation. Since wide climatic variations occur within distances of a few miles from the sea coast, the design could not safely be based on the dry bulb and wet bulb temperature standards applying in Los Angeles. Fortunately, extensive data were available at the nearby Union air terminal. These records were made the basis of an exhaustive study of heating, cooling, drying, and humidifying requirements. Consideration was given to the extremely high temperatures frequently recorded, as well as the occasional subfreezing night time temperatures, and the durations of these extreme conditions were also weighed to avoid any unnecessary enlargement of plant capacity. It was found that for many of the process rooms, humidifying and cooling will sometimes be needed concurrently, a departure from normal cooling practice. Before construction was begun, a full-scale test room was established to afford a demonstration of air distribution.

In all cases throughout the buildings, air flows are individually adjustable for the space served, and delivery into the rooms can be directed both horizontally and vertically in order to give correct air distribution. More than 750,000 cfm of air is to be moved by the 60 odd blowers being installed. For power they require roughly 320 motor hp.

The engineer in the central plant can determine individual air conditioner operation in all buildings by means of indicating lights. Further, he can check temperatures and humidities at various points in the buildings by use of a master indicating board.

In the celluloid storage vaults all paintings on celluloid are kept at even temperatures and humidities to guard against shrinkage which would disturb the all-important register of the sequence drawings. In addition, maintenance of correct air conditions protects the paint from deterioration.

Wherever the inflammable film is handled, as in the cutting building, automatic fire dampers are designed to slide over all air inlet and exhaust openings when released by a fusible link. The link would break readily if a fire should start, closing the air conditioning grilles.

Smoke Elimination Committees Present Recommendations to Mayor of St. Louis

TWO committees on elimination of smoke in St. Louis, Mo., recently presented their reports to Mayor Bernard F. Dickmann. One of the committees was a special group appointed by the Associated Engineering Societies of St. Louis of which Robert M. Boyles was chairman, and the other was the smoke elimination committee appointed by the mayor, chairman of which was James L. Ford, Jr.

In presenting its recommendations, the Associated Engineering Societies committee pointed out that much has been accomplished in reducing atmospheric pollution in St. Louis since enactment of the present ordinance in 1937, although much remains to be done. Broadly speaking, the solution of the smoke problem is obvious and simple, according to the committee: All persons must burn smokeless fuels or must employ mechanical equipment in the firing of potentially smoke producing fuels. Considering all uses, the greater part of the fuel consumed in St. Louis will continue to be unprocessed Illinois coal; any attempt at smoke elimination must recognize this and as a major essential must make provision requiring that this coal be burned smokelessly, either by controlled hand firing or by use of mechanical firing equipment. The first essential step toward smoke elimination is, therefore, that the use of mechanical firing equipment be made mandatory for all cases in which green, high volatile coal is to be burned, for previous experience based upon enforcement of controlled hand firing has proved constant supervision necessary.

A second essential step is that the use of natural or processed smokeless fuels be made mandatory for all cases in which mechanical firing equipment is not installed. For all power boilers and for the larger size heating plants, the date for compliance with the requirements should be the earliest practicable.

Smoke Elimination Committees Present Recommendations to Mayor of St. Louis

Two committees on smoke elimination in St. Louis—one appointed by the Associated Engineering Societies of St. Louis and the other appointed by Mayor Bernard F. Dickmann—recently presented their recommendations for solving that city's smoke problem. The first essential step toward smoke elimination is, the committees say, the use of mechanical firing equipment where high volatile coal is to be burned. . . . Amending of the present city ordinance or passing of a new ordinance embodying the following measures is suggested: (1) That all those burning a high volatile fuel must employ mechanical fuel burning equipment to burn it smokelessly. (2) That all others must use smokeless fuel. (3) That in case of emergency or necessary control, the city administration be authorized to engage in the purchase, sale and distribution of fuel. (4) That railroads should conform to the suggestions made in the committee report. (5) That the city, state and school buildings not subject to city regulations should be asked to coöperate. (6) That the division of smoke regulation should be enlarged to meet the increased demands made upon it in carrying out the powers of the revised or new ordinance

The committee concluded its report by comments on the coal processing situation and stated that it would be desirable to have smokeless fuels available from several privately owned plants and produced by a number of different processes. If, however, after the ordinance changes are enacted, private capital fails to make the processed smokeless fuels available in sufficient quantities or at reasonable prices, the city could take steps to meet the situation—either building a processing plant, contracting to purchase the output of some privately owned plant, or importing low volatile coals from eastern mining districts.

The report of the committee chairmanned by Mr. Ford discussed the importance of smoke elimination from the standpoint of safeguarding the health of the community as well as the material welfare of both the individual and the city. While it is difficult to measure damage to property values and expense of maintenance of both real and personal property caused by smoke, it is conceded that it runs into millions of dollars a year. It is admitted that raw bituminous coal can be burned with little smoke under the most favorable conditions but this certainly cannot be depended upon under ordinary conditions. One might as well argue, said the committee, that the city might furnish untreated river water to its citizens provided it gave them full directions and instructions on how to eliminate the impurities, and policed them to see that it was done.

Some have proposed that the city subsidize the price of smokeless fuel to the consumer, but the committee believes there is a grave danger in this principle. If the fuel bill of St. Louis citizens were to be raised out of proportion to that of other communities, some such action, though dangerous, might be warranted. When it remains substantially below that point (as indicated by a pamphlet issued by the United States Department of Labor) a subsidy of this kind would seem inexcusable to the committee.

The report then reviewed the distribution of smokeless fuel, the matter of smoke from railroads and from city, school and state buildings, and the reorganization of the division of smoke regulation. In conclusion, the committee recommended that the present ordinance be amended or a new ordinance be passed embodying the following measures:

1) That all those burning a high volatile fuel must employ mechanical fuel burning equipment to burn it smokelessly.

2) That all others must use smokeless fuel.

3) That in case of emergency or necessary control, the city administration be authorized to engage in the purchase, sale and distribution of fuel.

4) That railroads conform to the committee's suggestions.

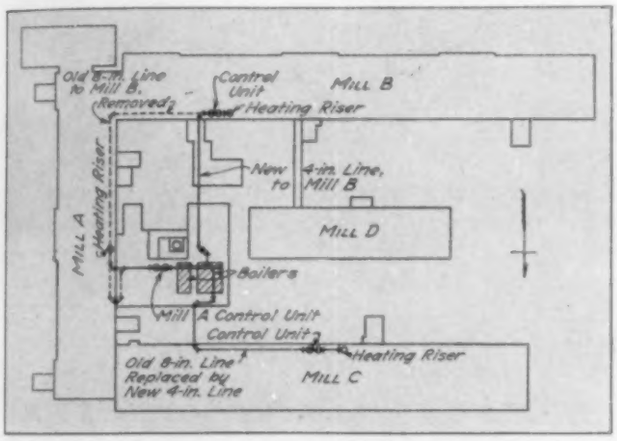
5) That the city, school and state buildings not subject to city regulation should be asked to coöperate.

6) That the division of smoke regulation be enlarged to meet the increased demands made upon it in carrying out the powers of the revised or new ordinance.

How We Improved the Heating of Our Plant

By H. A. Richardson*

SEVEN a.m. on a winter morning in a large silk mill. Outside, the temperature is 12 above zero and a northerly gale is roaring against the tall brick walls. Inside, the mercury is hovering around the 50 deg mark. Through the loosely fitting windows and frames the wind swirls, forcing a chill current of air across the full width of the mill room. A few looms have been started but loose ends of fibers fly in all directions and soon the banging of shuttles dies away as, one by one, the machines are shut down and the



Sketch of old and new piping arrangement

attempt to weave is abandoned. Along the walls the barely warm pipe coils are pitifully inadequate to build up the temperature. The foreman and superintendent confer and finally the latter calls out, "All right, boys, you may as well quit for today. We'll try again tomorrow." Disgruntled weavers start for home.

Conditions such as these, although infrequent, made it imperative to improve the heating system in one of our mills. Other reasons—especially economy of coal consumption—were important factors, too. The main goal was a minimum temperature of 72 deg in the mill rooms at all times during the heating season to eliminate lost time due to inadequate heat. At this mill the boilers, in addition to the heating load, had to maintain a minimum steam pressure of 55 lb per sq in. for a silk processing department. As it was essential to exercise strict economy in trying for these results, an approximation to ideal conditions was anticipated rather than its complete achievement.

This mill is engaged in the weaving and finishing of silks, real and artificial, including the auxiliary operations of winding, quilling and warping. All the buildings are over 50 years old. It might be of interest to note that in those days, before air conditioning, the site chosen for the mill was on low, swampy ground to take advantage of the natural humidity which tended to make the silk run more smoothly. The buildings are of fair mill construction with brick walls, timber floors and roofs.

*Vice-president, Phoenix Silk Corp.

Operation of the Old System

Heating is by direct steam coils, a two pipe system, with vacuum return. The layout of mains from the boiler room to the mills is shown in the sketch. Before the changes, two 4 in. pipe lines ran from the header, one supplying mill C and the other mills A and B. Each of these mains had a reducing valve near the boiler room and the pipe diameter was increased to 8 in. on the low pressure side. A heating riser near where the main entered mill A took off steam for that mill and the main continued through to supply mill B. This line is shown as a series of dashes on the sketch to distinguish it from the full lines of the revised construction.

The system did not have its radiation well balanced. The amount on the upper floors was about right to maintain reasonable temperatures in severe weather. On the lower floors the radiation was excessive for most conditions. Each floor had from six to 10 coils, individually operated by hand valves. The air infiltration was excessive. Practically all heating valves were kept open at all times during the heating season, except the main valves in the boiler room. As the mains supplying the floors had only two controls the system lacked flexibility.

In very cold weather the boiler capacity, as it was then employed, was insufficient to hold steam pressure in both

How We Improved the Heating of Our Plant

By H. A. Richardson

Proper heating is an essential to efficient operation of a manufacturing plant. In many older plants, unsatisfactory performance of the heating system is the cause of waste every day—not only in excessive fuel consumption but because of the loss it causes in the manufacturing process itself. In extreme cases, it may even mean complete shutdown on some days, as it did in the plant under consideration here. . . . . The particular plant used in our example of how industrial heating can be improved is a large silk mill, the buildings of which are over 50 years old. Poor heating was the cause of most unsatisfactory conditions at times. Changes in the heating layout—the piping arrangement, a means of control, some instruments, etc.—have been most successful in improving heating results; as to savings, it is believed that the cost of the improvements was absorbed in the first season. . . . . The actual changes made at this mill are not the most important point of the story—although they are of interest and may suggest to many others what might be done in their plants. The thing to remember is that poor heating costs money—more than is often realized—and that where this is the case it is possible—and essential—to do something about improving this important service

mains at the same time for more than a short period, perhaps half an hour. The practice was to open one main valve at the boiler room and pour steam into either mill C or mills A and B until the temperature on the top floors had risen to 80 deg if possible. The temperatures in the unheated section of the plant had meanwhile dropped below the comfort level. The steam valve was then closed and the other valve opened, heating the mill or mills connected with it in a like manner. The process was then repeated indefinitely. The fireman was obliged to make frequent trips through the mills, this being his only means of checking temperatures. Such a tour through the nine floors involved a walk of more than half a mile, a considerable task in addition to his regular firing duties when performed every hour or two.

The relatively greater amount of radiation on the lower floors resulted in excessively high temperatures at times because no attempt was made to control individual coils by hand valves. The upper floors were too warm at times and too cool at others, the latter condition causing continuous complaints.

Besides the bad effect of the constantly varying temperatures on the comfort and health of the workers, there were serious disadvantages from a manufacturing standpoint. There were occasions also (as noted earlier) when the mills could not be operated at all because of extreme cold or high winds. The production upsets and uncertainties which resulted can be readily appreciated.

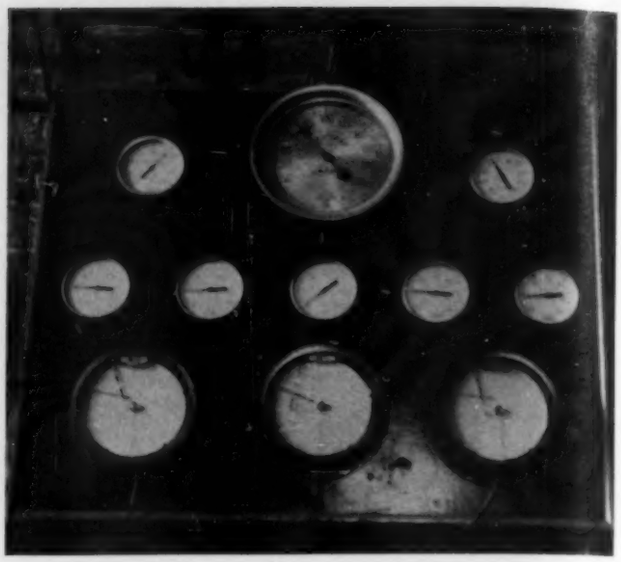
Piping Changes Decided Upon

The work of improvement had to be carried out by a few men from the plant maintenance force during the summer season and the possible expenditure was very limited. The plan adopted was as follows: Each mill was to be supplied by its own main, smaller in size than the existing large mains, which were scrapped. Each steam line was to be controlled by a motor operated valve, actuated by a thermostat on the top floor of the mill concerned. These valves would be under boiler pressure (120 lb per sq in.) and they would feed reducing valves which would bring the pressure down to about 5 lb per sq in. It was realized that this would offer only an approximate control of temperatures on the lower floors but in view of their ample radiation surface and the fact that the weather conditions, except for roof radiation, would be similar for all floors in one building, it was thought feasible to balance the heating by adjusting hand valves at the beginning of the season.

The layout of the new system is indicated in the sketch. The steam line to mill C is in the same location as was the older and larger main. The new mill A main is somewhat more direct and the mill B main is entirely new in location as well as material, giving a much more direct connection to that mill than did the old line. The location of the valve assemblies is also shown.

The advantages of the improvements are two-fold—those concerned with the generation and transmission of steam and those which are of benefit to the mill itself.

In the boiler room there has been a distinct operating benefit because of the even distribution of steam to the different buildings, this equalizing the boiler load and improving efficiency. No longer is the fireman required to leave the boiler room at frequent intervals and walk



This gage board indicates or records the various pressures and temperatures

through the mills, checking temperatures; he is able to use his time to better advantage in attending to his fires. A considerable steam saving is obtained by eliminating the overheating on the lower floors. At first it was thought that all three steam mains might, by opening at one time, draw abnormally large volumes of steam and make it impossible to keep up the required pressure. Such openings do occur but they have proven to be unimportant. A gage board in the boiler house shows, besides the boiler pressure, pressures on each of the mill rooms, the office (supplied by a manually controlled line) and the vacuum pump suction. Three recording gages give steam pressure and flue gas temperatures, and there is a CO_2 recorder.

Importance of Uniform Temperatures

In the mills the zoning system has been markedly beneficial to production. Silk processing can best be done under constant atmospheric conditions. The requirements for real and synthetic silk fabrics vary somewhat, but in general uniform temperatures and humidities for any particular material produce the best results. Looms run unsatisfactorily in an alternately cold and warm atmosphere because of the number of adjustments in materials which take place. Harness cords stretch or loosen, working parts slide smoothly or with excessive friction under varying conditions. Most important of all is the effect upon the fabric and threads of the goods in process. Low temperatures and the static electricity resulting from low humidities make weaving almost impossible at times. The movement of air due to infiltration accentuates this difficulty. Since it has been possible to keep temperatures constant within 2 deg, the above mentioned troubles have been greatly reduced.

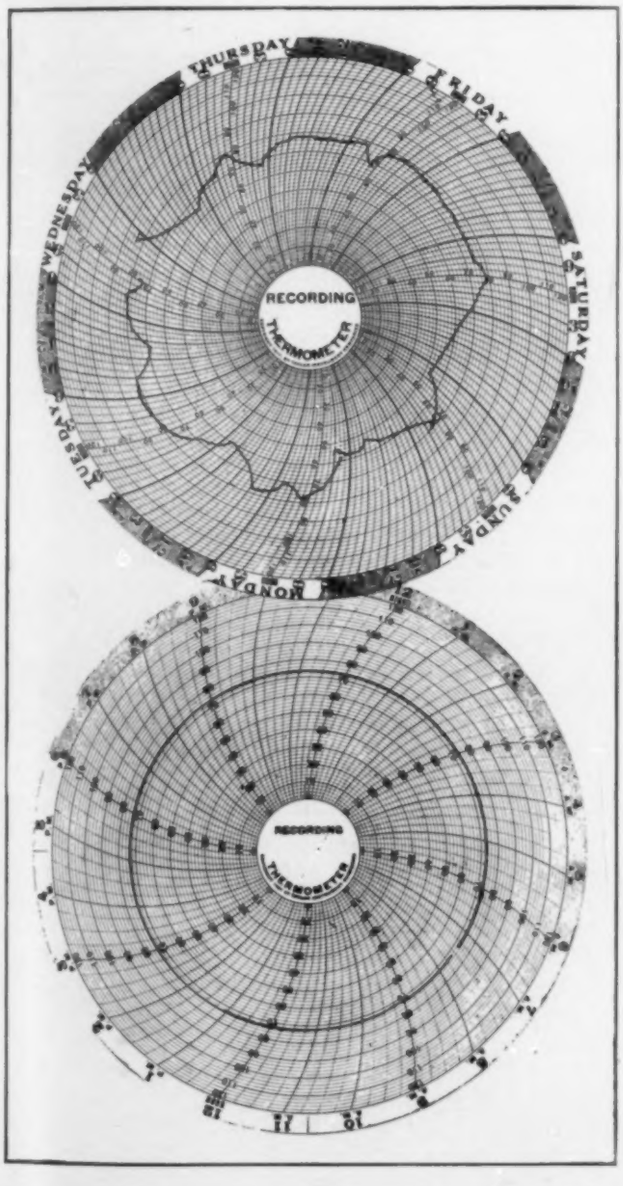
There has resulted a greatly increased comfort, and apparently better health, of employees. Under the old system of constantly changing temperatures it seemed either too hot or too cold most of the time. If too hot, windows were thrown open causing heat losses and undesirable drafts. If it was too cold, the workers were

uncomfortable even with extra clothing. There has been a noticeable diminution of colds and other respiratory diseases. Temperature regulation, if not entirely responsible for this, is certainly an important contributary cause.

The question of the optimum temperature was answered by experiment. At 70 deg there was some discomfort, more noticeable when there was a moderate or strong wind outside, the buildings being far from air tight. At 73 or 74 deg there is general contentment. In one mill room it has been necessary to add heat on occasions to compensate for the lack of humidification.

During the coldest winter months temperatures are maintained constant, day and night, except for week ends. There is 24 hr operation in one mill room and in the other rooms work usually continues until 10 p.m. On Saturday noons the thermostats are set back to 55 deg and kept at this figure until late Sunday afternoon or early evening, when they are stepped up one at a time in order to bring the mills up to their working temperatures 2 to 3 hr before work starts on Monday morning. This reduced temperature for week ends has proved economical in cutting coal consumption.

Charts from recording thermometers showing results without (above) and with (below) control. Although the one for no control, being for a week's run, accentuates the temperature changes as compared to the 24 hr chart with control, the latter is so nearly perfect variations on a weekly chart would be minor



Operation of Revised System

Some hand control of valves is still necessary on the lower floors. Each morning a man makes the rounds of the mills, taking temperatures at two or three points in each room and turning coils off or on if necessary. This requires very little time and is more useful as a check than because of the need of more than occasional adjustment. The mill workers are not depended on or even allowed to open or close valves without authority. An example of such supervision is as follows: One mill room has a large percentage of its looms running 24 hr a day during the week. With such occupancy and in ordinary winter weather, the motors, machine friction, lights, the bodily heat of the employees, and the heat from upper and lower floors make it unnecessary to use any steam for heating. When this activity stops on Saturday, however, the room cools off and steam must be used to bring it up to a comfortable temperature by Monday morning. The heat is then turned off for another week. Such instances are few and after a short period of practice they became known and are attended to almost automatically.

In order to distribute the load as evenly as possible it was hoped to be able to keep an amount of top floor radiation turned on that would heat the floor in the coldest weather and yet have the automatic valves close occasionally. In one mill room all the coils had to be kept turned on and on rare occasions, with a very low temperature and a high wind, the steam pressure has to be increased somewhat so that the room will be comfortable. On the other two upper floors, some of the coils are kept turned off even during the most extreme cold. On the lower floors it has been found that about half of the radiation is sufficient for all ordinary occasions.

The effectiveness of temperature regulation is indicated by the two charts, one of which is from a controlled mill room (C) and the other from one without control (D). Although the one for no control, being for a week's run, accentuates the temperature changes as compared to the 24 hr chart, the other is so nearly perfect variations on a weekly chart would be negligible.

One feature of the heating problem which has been impressive and which may not be sufficiently emphasized in texts on the design of heating systems is the preponderant influence of wind velocity both in radiation effects and in increasing infiltration, especially in the older buildings. With a zero temperature outside on a still day, the mills are heated much more easily than when the outdoor temperature is 20 or 30 deg higher and a moderately strong wind is blowing.

Minor Operating Difficulties

Certain minor difficulties have arisen in operating the system, as was to be expected. The motor operated valves did not always close promptly. This was usually the fault of the thermostat which was badly affected by

vibration when approaching a make or break in the circuit. Such vibration caused sparking and consequent burning of contact points. To overcome this condition, most troublesome in a weaving room, another type of thermostat was tried. This was unsatisfactory because it required too great a variation to operate—5 or 6 deg instead of 2 deg for the other type. The original thermostats were returned to service but were kept in condition by weekly cleanings and were suspended from the roof trusses to diminish the effect of machine vibration. The instruments are enclosed in small boxes of perforated metal, the doors of which are locked. It was found to be desirable to cover the tops of these boxes with felt pads to catch some of the dust and dirt which would otherwise float down on the contact points.

A setting of 72 to 73 deg, although at first considered low, has been found to be satisfactory. Air infiltration makes it necessary to change the settings at times. For example, in mill A (which faces eastward) 72 deg is acceptable with no wind stirring, but an easterly wind makes it necessary to raise the thermostat setting.

Certain modifications of full automatic control have proved justified in practice. During the milder weather of fall and spring the steam may be shut off the mains during most of the night, especially in the occasional cases when there is not all night mill operation. This allows a boiler to be banked for that period and the fire need not be broken up to supply steam at infrequent intervals. When one boiler is in service, rather heavily loaded, it is occasionally permissible to shut steam off the mills for half an hour when cleaning fires. It has been found that there is no tendency for the firemen to abuse the discretion they are allowed in this connection.

Paid for by Savings

After the first month of operation the system required a negligible amount of attention and it is considered that its cost was absorbed by the savings it made possible in one season. It is now on its third successful season and the only remaining building used for manufacturing (D), has just recently been put on full automatic operation.

Thickness of Steel for Tanks

A reader asks for a formula for computing the thickness of steel for vertical storage tanks.

There was published in the May, 1935, HPAC an article by Kalman Steiner on design and erection of a bulk fuel oil storage plant, which included a formula for figuring thickness as follows:

$$t = \frac{0.434\,H\,D}{2\,s}$$

where t = thickness of metal, in.;
H = height of tank, ft;
D = diameter of tank, in.;
s = allowable working stress, lb per sq in.

The constant in the formula, 0.434, is based on a specific gravity of 1. If some other specific gravity value is to be used, the constant should be multiplied by that specific gravity. For instance, if the specific gravity were 0.9, the constant would be 0.9×0.434, or 0.391.

Florida Hotels Install Heating

By John B. Swift*

In the days before the real estate boom, it was standard practice to omit heating equipment from buildings in southern Florida. At that time it was the belief that there were so few days requiring heat that anything beyond an open fireplace was a needless luxury. At the beginning of the "boom days," however, when northern capital came in to design and build large hotels, a heating plant was added as a matter of course. Ever since there has been a drift of patronage from the unheated to the heated hotels, the unheated holding their guests from year to year largely through sentiment and a natural desire of the steady patrons to meet old friends every season at the same old winter home. A few days' dis-

Florida Hotels Install Heating
By John B. Swift

The past winter in Florida, with its record breaking duration of really cold weather, has made it necessary for unheated hotels to give consideration to installing heating equipment. Many patrons have notified their hotel managers that unless some form of heating equipment is installed before next season, they will go to a hotel that does have it. . . . . Even open air amusement places are being compelled to supply heating; a dog race track, for example, installed steam unit heaters with vertical discharge on the grandstand seats, and horizontal heaters blanketing the open front of the grandstand.

comfort was overlooked, just as one will overlook such things in his own home. The past winter, however, with its record breaking duration of really cold weather, has brought matters to the breaking point. Many of the old-time patrons have notified their hotel managers that unless some form of heating equipment is installed before next season, they will make no reservation and will be found next year in a heated hotel.

Even open air amusement places are being compelled to add heating comfort. One Miami dog racing track installed an elaborate heating system in its grandstand this year, and obtained the majority of the attendance. This was an installation of steam unit heaters, with vertical discharge on the grandstand seats, and regular horizontal discharge heaters blanketing the open front of the grandstand.

In the writer's unheated hotel the guests practically all purchased some form of electric heater for their rooms, resulting in a complete "blackout" for three nights, besides the fire hazard due to greatly overloaded old wiring.

The older buildings often are economically limited to some form of electric heat, it appears, because of the lack of basements in which to install boilers and by the cost of tearing out walls, etc., for the piping. The prevailing idea at this time is the installation of electric unit heaters blowing down the halls and in the larger rooms, and blower type electric radiators or heaters in the smaller rooms. The situation is of course intensified in the north part of the state.

While it often has been characteristic for chambers of commerce to deny to manufacturers the existence of a market in Florida for unit heaters, the present unusually cold season has demonstrated otherwise. The writer has personal knowledge of many large and small installations contemplated for the coming year.

*Factory Representative.

The Psychrometric Chart

Its Application and Theory

By William Goodman*

THE fundamental construction of the psychrometric charts presented here is illustrated in Fig. 32. The ordinate of these charts is absolute humidity; the abscissa, enthalpy. The lines of constant enthalpy could be vertical, but, for reasons that will be apparent later, these lines of constant enthalpy are inclined.

Geometry of the Psychrometric Chart

As shown in Appendix 8, the enthalpy of either a saturated or unsaturated air-vapor mixture is given by the following formula:

$$h = (0.24 + 0.45w)t + 1061w \quad [41]$$

In Fig. 32 the horizontal distance *1-3* from the line of zero enthalpy ($h = 0$) to any point on the chart such

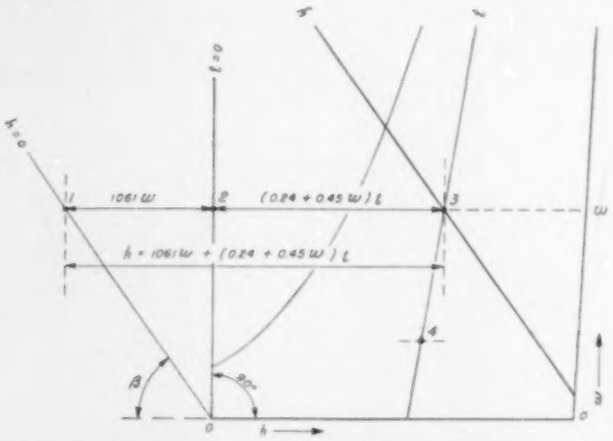


Fig. 32—Illustration showing skeleton construction of psychrometric chart and interpretation of horizontal distances when state point lies in the clear field of the chart

as *3* is proportional to the enthalpy of the air-vapor mixture at that point. On the other hand, the horizontal distance *1-2* between the line of zero enthalpy ($h = 0$) and the line of zero dry bulb temperature ($t = 0$) is proportional to the value of $1061w$ as shown in Appendix 8.

The horizontal distance *2-3* from the line of zero degrees dry bulb temperature ($t = 0$) to any point on the chart such as *3* is directly proportional to $(0.24 + 0.45w)t$. However, the quantity $(0.24 + 0.45w)$ is equal to c, the humid specific heat of the air. For this reason, the horizontal distance from $t = 0$ to any point on the chart, such as *3*, is proportional to the sum of the sensible heat of the dry air and sensible heat of the superheated vapor in the air-vapor mixture.

If the sensible heat of the superheated vapor mixed with the air were ignored, all of the dry bulb temperature lines would be parallel to each other because, in such a case, the sensible heat of the air would be equal to $0.24t$. But, because of the sensible heat of the superheated water vapor mixed with the air, the dry bulb temperature lines are not parallel to each other; they diverge at a slight angle. In Fig. 32 at point *3* the weight of moisture mixed with the air is greater than the weight at point *4*. Accordingly, even though the dry bulb temperature is the same in both cases, at point *3* the sensible heat of the greater weight of vapor mixed with the air is larger than at point *4*. For this reason point *3* must lie to the right of point *4*.

For psychrometric Charts A to F inclusive the line for dry bulb temperature of zero degrees ($t = 0$) was drawn at an angle of 90 deg with the horizontal lines of absolute humidity. However, the line of zero degrees dry bulb temperature need not necessarily be drawn perpendicular to the horizontal lines of absolute humidity—such a line can be drawn at any desired angle that is arbitrarily selected. This is discussed more fully in Appendix 9. If the line of zero degrees dry bulb temperature is inclined at an angle to the horizontal, all of the other dry bulb lines will also be inclined although they still will not be parallel. By drawing the line of zero degrees dry bulb temperature at a 90 deg angle, a chart is obtained that has the familiar appearance of the older charts that have been used heretofore. Furthermore, such a chart is easy to read because of the sharp angle between the almost vertical lines of dry bulb temperature and the sloping lines of enthalpy.

On a chart in which the coördinates are absolute

Symbols Used in Text

(For complete list see p. 358, June, 1939, HPAC)

- c = humid specific heat of air-vapor mixture ($c = 0.24 + 0.45w$)
- h = enthalpy of air-vapor mixture, Btu per lb of dry air in the mixture
- h_g = enthalpy of moisture in vapor state, Btu per lb of vapor
- q = moisture ratio, Btu per lb of moisture evaporated into the air or condensed from it
- s_H = scale to which enthalpy lines are drawn on psychrometric chart, Btu per in. of scale length
- s_M = scale to which absolute humidity lines are drawn on psychometric chart, lb of moisture per in. of scale length
- t = dry bulb temperature, deg Fahr
- w = absolute humidity of the air-vapor mixture, lb of moisture per lb of dry air in the mixture
- θ = moisture ratio angle (see Table 1, p. 422, July, 1939, HPAC)
- β = slope of enthalpy lines

*The Trane Co. Member of Board of Consulting and Contributing Editors.

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The Psychrometric Chart
Its Application and Theory

By William Goodman

Everyone engaged in air conditioning and drying work makes use of psychrometric charts, but few know much about how they are constructed. Something of the geometry of these indispensable "tools" is described and discussed here, and the skeleton chart which is presented illustrates the significance of the various factors involved. . . . The series of which this article is a part includes new psychrometric charts for the low, medium and high temperature ranges, discussion of the theory underlying them, and instructions and methods for solving problems encountered in air conditioning work

humidity and enthalpy, all of the lines of dry bulb temperature will be straight lines, but the slope of the lines for each dry bulb temperature will be different. This is apparent from the following equation derived in Appendix 4.

$$q = h_s = 1061 + 0.45t \quad [42]$$

For any one dry bulb temperature, the right-hand member of equation 42 reduces to a constant. Hence, the dry bulb temperature lines will be straight lines. However, inasmuch as the dry bulb temperature appears in the right-hand member of [42], the slope of each line of dry bulb temperature will be different, and will depend upon the value of the dry bulb temperature for which the line is drawn. The actual method of drawing the dry bulb temperature lines on the chart is relatively simple.

The easiest method of drawing the dry bulb temperature lines on a psychrometric chart is to make use of the fact illustrated in Fig. 32 that the distance between a point on any dry bulb temperature line and the line of $t = 0$ is directly proportional to the quantity $(0.24 + 0.45w)t$. If $w = 0$, $h = 0.24t$. This equation is used to compute the points at which the various dry bulb temperature lines will intersect the horizontal line of $w = 0$. Then by choosing a value of w such that the quantity $(0.24 + 0.45w)$ reduces to some value like 0.25, the points for the various dry bulb temperatures can be laid out along the horizontal line of absolute humidity, w, that was selected. Then each line of dry bulb temperature can be drawn through the point on the line of $w = 0$ and the point on the line of w for which the humid specific heat, c, is equal to, say, 0.25.

Although, at first thought, it may appear that the slope selected for the enthalpy lines is immaterial, this is not the case. The slope of the enthalpy lines is given by the angle β of Fig. 32 and its value plays a part in making the chart more usable in connection with the important moisture ratio lines. This is discussed in more detail later.

The value of the angle β depends upon the scales used in drawing the chart. As shown in Appendix 9, the relationship between the angle β of Fig. 32 and the scales for which the chart is drawn is given by the following equation.

$$\tan \beta = \frac{s_H/s_M}{1061} \quad [43]$$

This equation is valid only as long as the line of zero dry bulb temperature is drawn vertically, that is, at an angle of 90 deg with the horizontal. The general equation which must be used when the line of zero degrees dry bulb temperature is inclined to the horizontal is given by [5] of Appendix 9.

In order to draw the ratio lines on the psychrometric chart, the ratio angles corresponding to the various moisture ratios must be known. These angles were given in Table 1† and they may be computed by means of either one of the following equations derived in Appendix 10. These equations also are valid only if the line of zero dry bulb temperature is vertical.

†Table 1 was published on p. 422, July, 1939, HPAC.

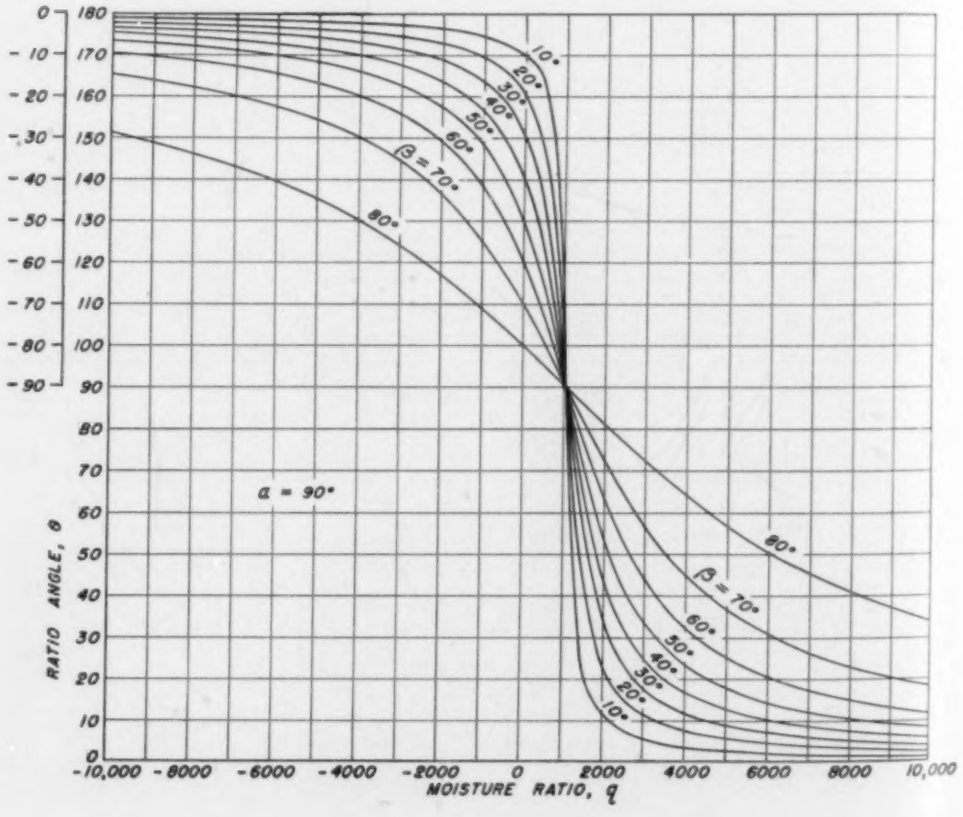


Fig. 33—Chart showing variation in ratio angle θ with moisture ratio q for various values of the angle β. This chart is applicable only when $\alpha = 90$ deg. For this illustration, α is the angle which the line of 0 deg dry bulb temperature makes with the absolute humidity lines

$$\cot \theta = \frac{s_M}{s_H} q - \cot \beta \quad \text{.....[44]}$$

By eliminating s_M/s_H between [43] and [44] as shown in Appendix 10, the following equation is obtained for the ratio angle.

$$\tan \theta = \frac{1061 \tan \beta}{q - 1061} \quad \text{.....[45]}$$

In order accurately to locate and draw ratio lines on the psychrometric chart, the value of the ratio angle θ should change as uniformly as possible for uniform changes in the value of the moisture ratio, q. As is evident from Fig. 33, such an approximate uniform change in the value of the ratio angle θ is possible only for large values of the angle β. For small values of the angle β, the change is far from uniform. For example

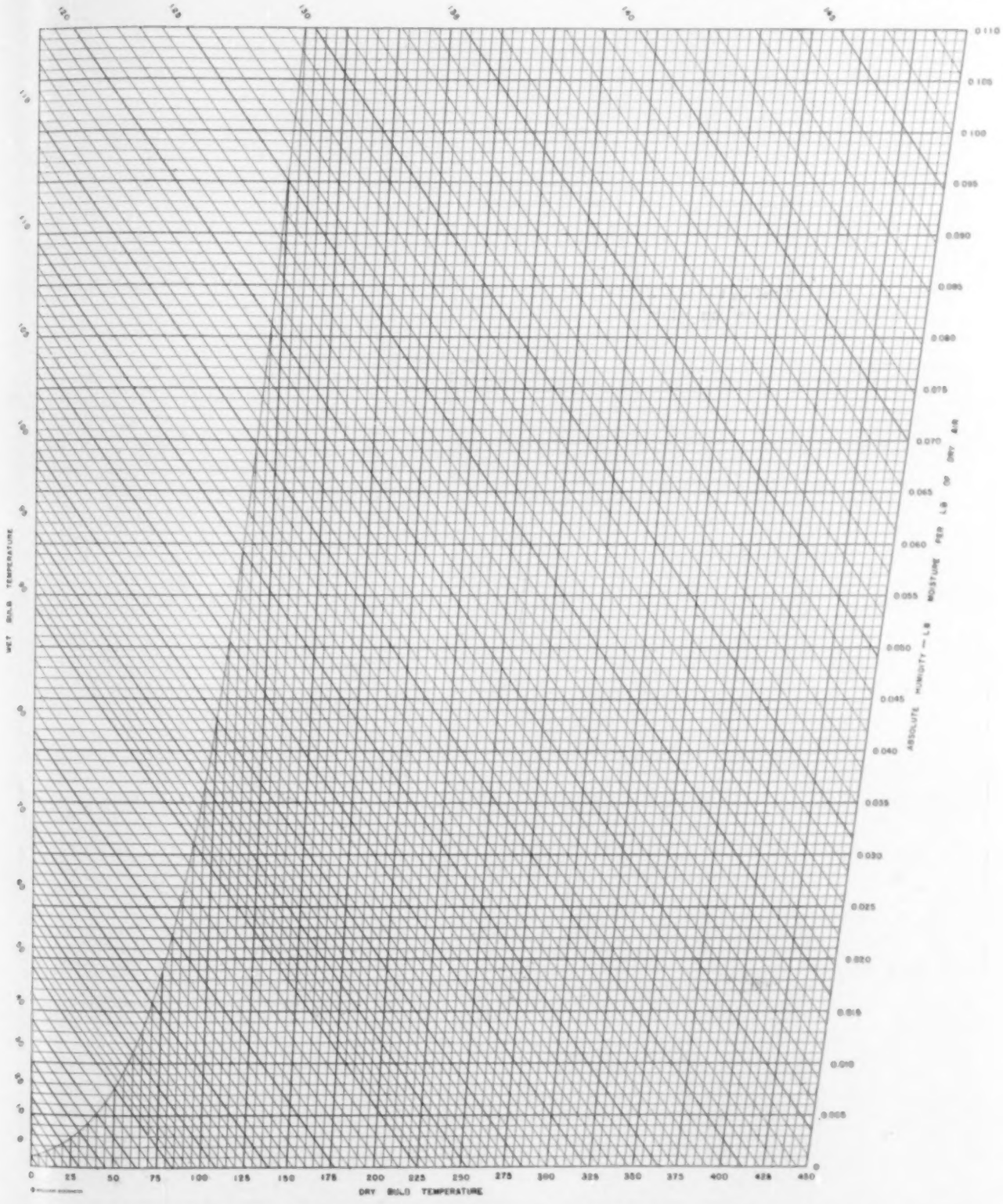


Chart E—This chart is to be used only for the normal barometric pressure of 29.92 in. of mercury. Lines of constant wet bulb temperature are shown instead of lines of constant enthalpy

if $\beta = 10$ deg, the value of the ratio angle θ changes very rapidly for values of q between approximately —1000 and +3000. Above +3000 and below —1000, the value of the ratio angle remains almost constant for all values of the moisture ratio q. On the other hand, referring to equation 43, it is evident that in order to obtain a large value of the angle β, the value of s_M must be made as small as possible, and the value of s_H as large as possible. This requires a chart with a long vertical scale of absolute humidity and a short horizontal scale of enthalpy for any given range of enthalpy and humidity. For this reason, when constructing the psychrometric chart, a compromise must be made between a large value of β and a chart that will have the proper proportions so that the desired ranges of enthalpy and absolute humidity can be plotted and read with a sufficient degree of accuracy.

Charts A and B,** which have a long vertical scale of absolute humidity and a relatively short horizontal scale of enthalpy represent what was felt to be the best compromise. For all the charts of this article, $\beta = 53°\text{-}25'$.

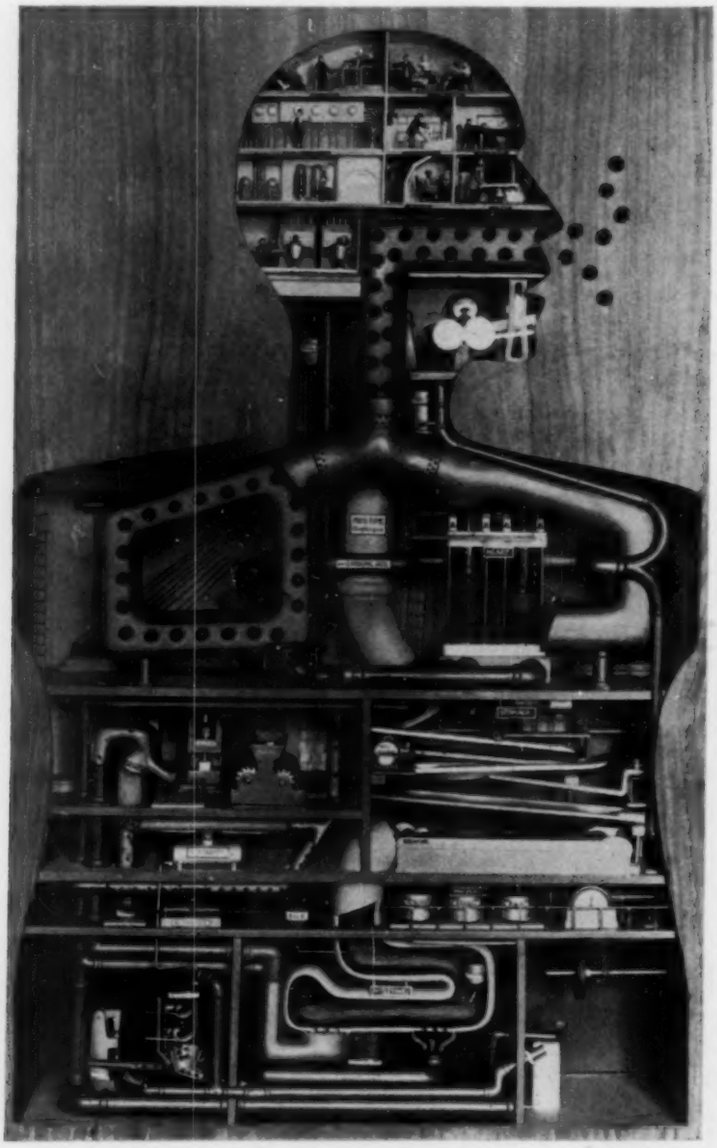
[To be continued]

**Charts A and B were published on p. 359, June, 1939, HPAC and p. 750, December, 1939, HPAC, respectively.

Human Body Just a Heating, Piping and Air Conditioning System

The human body isn't much more than a rather complicated assembly of heating, piping and air conditioning apparatus, judging from the novel display of the "human factory" in the Hall of Man, Buffalo Museum of Science, Buffalo, N. Y., to which institution we are indebted for the information and picture presented here. The model is equipped to illustrate most of the functions of the body, as the following description of only the "department of digestion" and of the "ventilating system" will indicate.

Solid and liquid raw materials enter the body through the mouth. Note in the figure the guillotine, cutting off suitable portions, which are then led to the grinding rollers. Lubricating saliva is fed into the mass from a tank at the rear. Through a chute labeled "food pipe," the food is then dropped into the stomach, where tanks supply hydrochloric acid and pepsin and the mixture is thoroughly blended. Moving across in front of the observer, it is led to the discharge valve which opens into the intestine. In this receptacle, from tanks marked "fat," "starch," and "albumin," materials are added to treat these essential food elements properly, the rate of flow being indicated by a registering gage. Through the first of two perforated gratings, corresponding to the lacteals, passes food material sufficiently treated to be carried directly into the blood stream. Then moving to the second grating the current discharges the less finished materials. There is a big pipe (the portal vein) by which the latter portion is carried to the liver.



In the liver the sugars go through the process of refining and pressing, and a stack of this treated sugar, or glycogen, is put aside till needed. Toxins or poisons are filtered out and piped to the bile tank, which overflows into the intestine. Tiny drops of urea (blood waste) pass into the kidney, whence they are discharged into the sewer.

Now for the ventilating system. In through the stack, represented by the nose of the figure, passes a stream of red lights, representing the oxygen or fresh air. It travels down the trachea, the two bronchial tubes, and into the lungs, whence a pipe leads it into the left side of the heart, whose two pistons, working like those of a pump, force the blood out through the great vessels of the circulatory system. From the right side of the heart blue lights lead back again to the lung and up the smoke stack, where waste gases are carried out.

Human Body Just a Heating, Piping and Air Conditioning System
This exhibit of the "human factory" at the Buffalo Museum of Science is equipped to illustrate most of the functions of the human body, such as the "department of digestion" and the "ventilating system", which are described here. Looking at the picture, it is seen that the human body is not much more than a rather complicated arrangement of heating, piping and air conditioning

Corrosion in Steam Heating Systems

Feedwater Treating System in Central Heating Plant

By Leo F. Collins* with Everette L. Henderson†

THE feedwater treating system under consideration is situated at the Congress St. heating plant of The Detroit Edison Co., which plant produces annually about 725,000,000 lb of steam. The steam demand is variable; at night during the early fall months it may be as low as 10,000 lb per hr and on cold winter days as much as 390,000 lb per hr. Hourly variations of 50,000 lb per hr are not uncommon on a typical winter day. About 30 per cent of the boiler input is returned condensate and the remainder is make-up water derived from the city supply.

Prior to the adoption of the cycle to be described, the feedwater treating equipment was arranged as shown in Fig. 27. A fixed amount of acid sufficient to neutralize about 60 per cent of the alkalinity was added to the zeolite softened make-up water. Both the make-up water and returned condensate were then passed through an atomizing type deaerating feedwater heater enroute to the boilers. Continuous blowdown through a heat exchanger was utilized to maintain boiler water concentrations within predetermined limits. With this arrangement the normal conditions that existed at various key points in the cycle were as indicated in Table 15.

From a plant operating standpoint these conditions were quite satisfactory, but the CO_2 content of the steam was such that serious corrosion of heating equipment could occur if other necessary factors were active. Because of this—and after considerable study—it was determined that experiments on a plant scale should be run to test the producing of a steam of lower CO_2 content.

First Endeavor

The first endeavor in this regard involved the addition of enough acid to neutralize almost completely the make-up water. This water was then passed through the regular plant cycle. A summary of the results obtained in tests of this nature is also shown in Table 15.

While the tests demonstrated that a steam of very low CO_2 content could be produced, the low pH value of the water in the feed lines was believed to be conducive to severe corrosion of the piping. It was therefore concluded that if this basic method of CO_2 elimination was to be practical, means of producing higher pH values would have to be provided.

Accordingly (and for many detailed reasons which need not be reviewed) it was concluded that if the acid feed was regulated so as to provide a residual bicarbonate alkalinity of 10 ppm (with a permissible variation of ±5 ppm) and if the water was subsequently passed through an efficient aerator, enough CO_2 would be removed to bring corrosion of the cold water piping within tolerable limits; that the remaining gaseous CO_2 and a small part of the combined CO_2 would be removed in the deaerator. So long as the boiler water was distinctly alkaline, the steam produced would contain not more than 5 ppm** of CO_2 and no oxygen.

The New Cycle

When the design of the new cycle was under initial consideration, the questions of basic importance were: Can an acid proportioning device of the required accuracy be obtained? What is an efficient aerator and where can it be obtained? A study of commercial acid proportioning devices then available led to the conclusion that none would adequately meet the requirements and that therefore one would have to be developed. One of

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†Professor of Chemistry, University of Detroit.

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**It was recognized that an upper limit of 2 ppm is the objective to be sought. Still it was felt that since the development of this system was primarily an experiment it would be prudent in the beginning arbitrarily to set a somewhat higher limit. It will be shown later that, even though this limit is still in existence, the average CO_2 content of the steam is of the order of 2 to 3 ppm.

Corrosion in Steam Heating Systems
By Leo F. Collins with Everette L. Henderson

Preceding sections of this series have dealt with the aspects of the problem of corrosion in steam heating systems in two general ways. Those expedients which provide more or less temporary relief were considered and later the possibilities of eliminating the basic causes and thus effecting a permanent remedy were reviewed. . . . . It is evident from the data which have been published so far that the most comprehensive expedient which can be adopted, especially by district heating companies, is a reduction of the deleterious gas content of the steam. This, as a usual thing, will involve very exact control of the boiler feedwater treatment. Moreover, some of the benefit which should accrue will be lost if the heating systems served are not carefully designed, well maintained, and properly operated. . . . . It is hoped that those considering the feasibility of CO_2 removal will obtain, from the experimental data presented, an appreciation of some of the complexities involved. Then, too, it will be well to remember that this phase of water treatment is so new that little experience has yet been obtained. For this reason the claims made for certain schemes are sometimes based only upon deductions. Thus, those charged with such a development should at least have a sufficient technical background to judge whether or not the schemes proposed are inherently capable of giving the results predicted. . . . . The last section of this paper (starting this month) describes in detail a water treating scheme that has been developed in a large central heating plant to produce a steam containing not more than 5 ppm [parts per million] of CO_2 and no oxygen

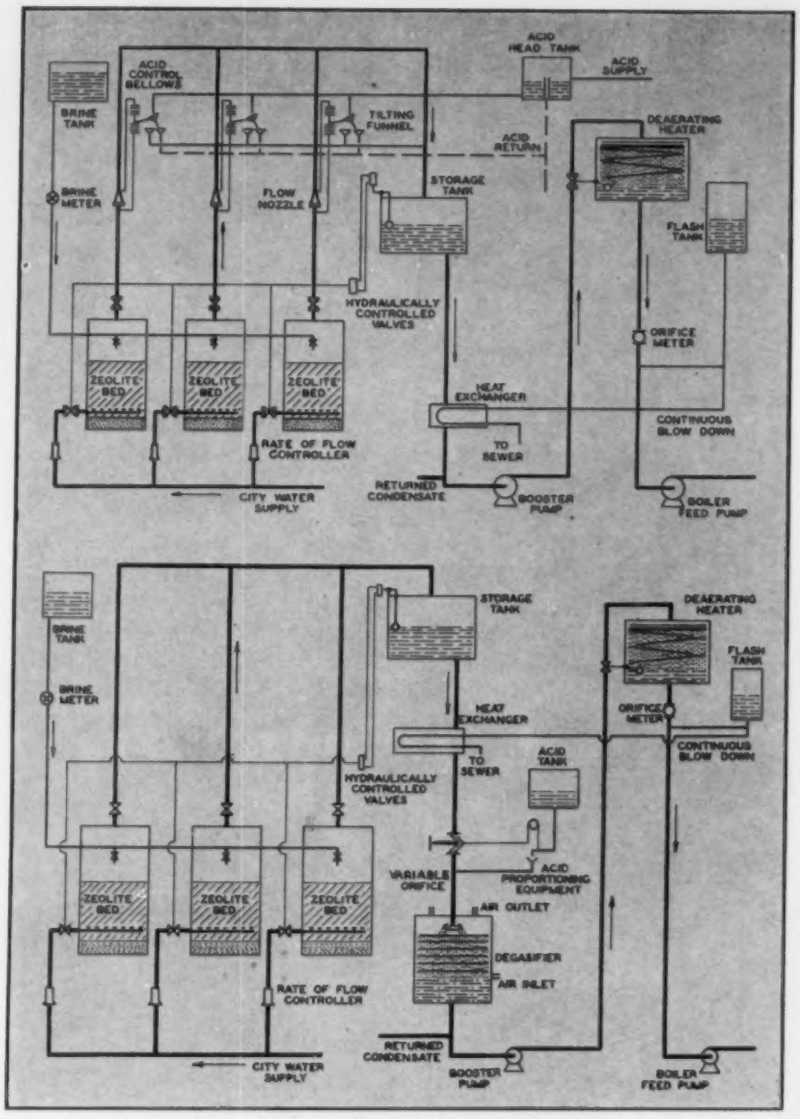


Fig. 27 (above)—The old feedwater cycle
Fig. 28 (below)—The new feedwater cycle

several companies contacted was willing to assume responsibility for designing and furnishing an aerator.

The present cycle was initially considered as experimental. An effort was made in its design not only to utilize the feedwater equipment already available, but also to leave the old system intact. As a result, therefore, the new cycle is not radically different from its predecessor. In reality it is simply a refinement of the older one and contains only four new or added features. These are: (1) A more exact means for preparing dilute acid. (2) An accurate acid proportioning device. (3) An aerating tower for removing CO_2 from the cold, acid treated water. (4) A system for feeding caustic soda to each boiler. The arrangement of the new cycle is shown in Fig. 28.

Preparation of the Dilute Acid—Since there were no known means of controlling an acid proportioning device by chemical changes it was necessary in developing the present apparatus to resort to the use of physical changes, i.e., volume-for-volume proportioning. However, the addition of acid must be on a weight-for-weight basis. So it is obviously true that the proportioner cannot perform satisfactorily unless the acid is of a constant predetermined strength.

With the old system, when only about 60 per cent of the alkalinity was being destroyed and the acid feed was fixed, a somewhat variable strength of acid was satisfactory. It sufficed to prepare dilute acid by measuring the concentrated acids volumetrically. Under the exacting conditions of the new system this did not always provide an acid of required strength. The principal reason for the deviations was found to lie in the changing density of concentrated acids

Table 15—Comparative Conditions at Key Points in the Feedwater Cycle Under Three Different Operating Conditions

(All figures are parts per million except pH values)

	Make-up Water		Normal Conditions With Old System					Preliminary Test Conditions When "Excess" Acid Was Used With Old System					Average Conditions With New System					
	Raw	Zeolite Softened	After Addition of Acid	To Deaerator[a]	Leaving Deaerator	In Boilers	Steam	After Addition of Acid	To Deaerator	Leaving Deaerator	In Boilers	Steam	After Adding Acid (Degasifier Influent)	Degasifier Effluent	To Deaerator[a]	Leaving Deaerator	In Boilers	Steam
Silica, SiO_2	1	4	4	3	3	20	—	4	3	3	20	—	4	4	3	3	20	.....
Oxides, Fe_2O_3 & Al_2O_3	1	2	2	1	1	12	—	2	1	1	12	—	2	2	1	1	12	.....
Calcium, Ca	25	1	1	1	1	2	—	1	1	1	2	—	1	1	1	1	2	.....
Magnesium, Mg	6	0.2	0.2	0.2	0.2	0.2	—	0.2	0.2	0.2	0.2	—	0.2	0.2	0.2	0.2	1	.....
Sodium & K (as Na)	5	48	48	43	43	600	—	48	43	43	600	—	48	48	43	43	600	.....
Bicarbonate, HCO_3	98	98	44	33	30	0	—	7	6	6	0	—	10	10	7	6	0	.....
Carbonate, CO_3	0	0	0	0	2	12	—	0	0	0	10	—	0	0	0	1	10	.....
Hydrate, OH	0	0	0	0	0	100	—	0	0	0	50	—	0	0	0	0	100	.....
Phosphate, PO_4	0	0	4	3	3	30	—	4	3	3	30	—	4	4	3	3	30	.....
Sulphate, SO_4	21	21	60	45	45	1000	—	90	80	80	1000	—	86	86	79	79	1000	.....
Chloride, Cl	6	6	6	5	5	100	—	6	5	5	100	—	6	6	5	5	100	.....
Dissolved Solids	120	130	155	100	100	2000	< 5	170	153	153	2000	< 5	170	170	153	153	2000	< 5
Hardness as $CaCO_3$	89	3	3	2	2	6	—	3	2	2	6	—	3	3	2	2	9	—
Oxygen, O_2	13	13	13	8	0	0	—	13	8	0	0	0	13	13	13	0	0	0
CO_2 (Free)	2	2	40	30	0	0	14	52	40	7	0	1	30	10	10	0	0	3
pH Value[b]	7.1	7.9	5.8	6.4	8.7	11.6	5.4	5.2	5.2	6.6	11.4	7.0	5.2	6.4	6.4	8.0	11.6	6.0
Temperature, F	40	40	40	80	220	356	356	40	80	220	356	356	40	50	80	220	356	356
Pressure, lb per sq in.	55	—	—	—	2.5	130	130	—	—	2.5	130	130	—	—	—	2.5	130	130

[a] Contains about 25 per cent returned condensate.
[b] All pH values were measured at room temperature.

(particularly sulphuric acid) with changing temperature.

The difficulty was overcome by providing means for weighing the concentrated acids. A spring scale was equipped with a small, lead lined tank. The required amount of acid is now weighed to within ½ lb, is introduced into the mixing tank (previously filled with water), and the solution is then mixed with an air agitator for about 15 min, after which a sample is checked with an hydrometer. If necessary, a correction can be made. The acid mixing equipment is shown in Fig. 29.

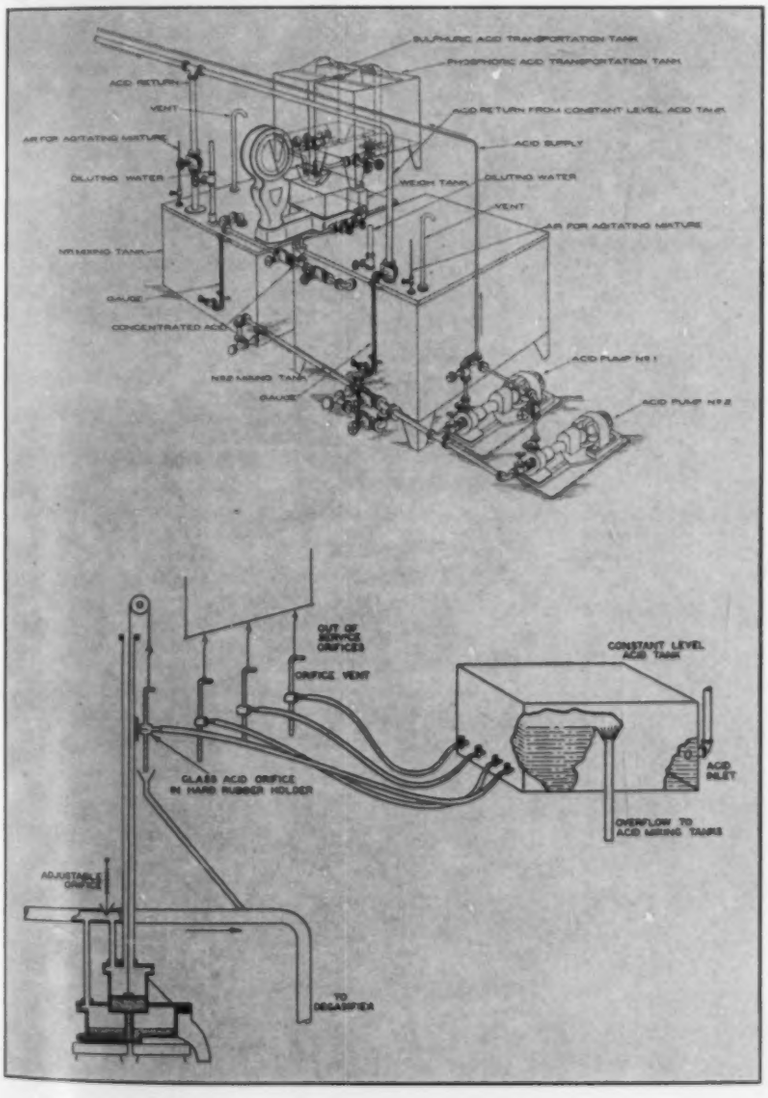
Multiple dilute acid tanks and duplicate acid pumps are regarded as a necessity. This would not necessarily be true of a system in which storage of acid treated water is provided. In the present system the acid is added only to the water flowing to the boilers and it is therefore necessary that a continuous supply be available. To meet this requirement some outage of acid pumps must be contemplated. The same is true for the dilute acid tanks because of the time required to prepare the dilute acid solutions.

Acid Proportioning Equipment — In designing the acid proportioning equipment it was necessary to provide not only for large and sometimes rapid load fluctuations but also for changes in raw water alkalinity—both of which might occur simultaneously. In the scheme finally adopted load changes are compensated for primarily by the proportioning device itself. A variable orifice which actuates the proportioning device can be made to assist in compensating for load changes and it is used exclusively to correct for changes in alkalinity.

The apparatus used is shown in Fig. 30. Basically it is the same as the one described by J. H. Walker and L. F. Collins in *Power*, April 8, 1930, and was developed by The Detroit Edison Co.'s engineers. A feature of the present apparatus is the hard rubber heads for holding the thin plate type glass acid orifices. Initially the vent pipe was not included. Experience soon demonstrated that air accumulations at the orifices seriously affected their accuracy. Hard rubber and stainless steel orifices were also used with unsatisfactory results. Another feature is the funnel shaped overflow line which prevents a fluctuation of more than ⅛ in. in head on the acid orifices.

Four acid orifices of varying diameters are provided but only one is used at a time (multiple orifices are necessary because the limits of travel are quite close). Due to existing plant piping arrangements it is impossible to obtain a differential pressure in excess of 112 in. of water upon the mercury chamber. The corresponding travel of the float (8 in.) could not all be fully used because of the small deflection for increments of flow at the lower end of the range.

Fig. 29 (above)—The acid handling and mixing equipment. Fig. 30 (below)—The acid proportioning device



Adjustable Orifice—In order to create the differential pressure necessary to actuate the acid orifices under all plant requirements an adjustable orifice was installed in the water line to the aerating equipment. It is essentially a gate valve, the stem of which is accurately calibrated to show the location of the gate. This is the trigger of the acid proportioning apparatus. The differential pressure resulting from the flow of water through the restricted opening is transmitted to the mercury chamber of the proportioning device. This raises or lowers the acid orifice in proportion to the square of the flow of water through the adjustable orifice.

Aerating Tower—A sketch of the equipment, indicated as the "degasifier," is shown in Fig. 31. It is made of cypress. The acid proportioning device was situated as close as possible to the degasifier to minimize corrosion in the lines handling this water before aeration.

The degasifier is of telescopic design. The upper smaller section contains a water box to insure complete mixing of acid and water (which is highly essential), a distribution deck, and staggered horizontal wood baffles. The lower section, which is lead lined, acts as an air seal and storage reservoir. Air is introduced between the two sections and flows countercurrent with the water. It discharges through vent pipes to the atmosphere through a "water eliminator," which consists of a series of directing vanes that change the direction of air flow at rather sharp angles. This tends to coalesce the water droplets and as their mass increases they separate out due to centrifugal action.

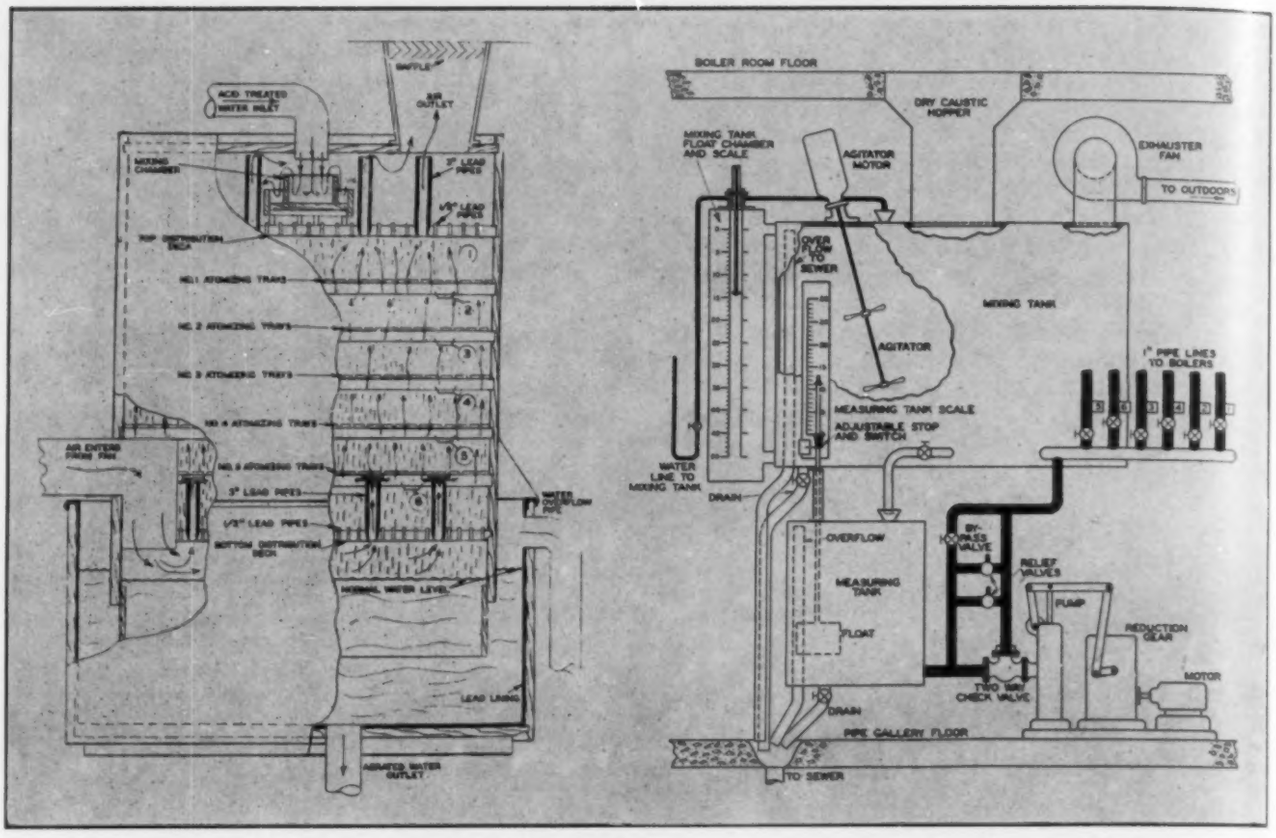


Fig. 31 (left)—Sketch of "degasifier." Fig. 32 (right)—Caustic mixing and measuring tanks and pump for feeding caustic to boiler.

Caustic Feeding System—At first, caustic soda was fed to each boiler by means of a portable pump. This arrangement, however, was never considered satisfactory, particularly because of the attendant danger. While no serious accidents occurred, the temporary expedient was replaced with the system outlined in Fig. 32.

In this system a 10 per cent caustic solution is prepared and stored in the mixing tank. A small volume of the solution is introduced into the measuring tank from which it is pumped into a manifold and thence to the main feed line of the desired boiler. A mercury switch attached to the float in the measuring tank stops the pump when the desired volume of solution is added to the boiler.

By this arrangement handling of caustic is held to a minimum. The caustic, in barrel lots, is added to the storage tank to which a predetermined amount of water has been added. An exhaust fan removes the objectionable fumes while the tank is being charged.

Note—In the second sentence of the last paragraph of the March installment the phrase "this type of equipment" was inadvertently used. In an attempt to keep the text in strict accordance with the data presented, it is the author's desire to correct this phrase to read simply "this equipment." *[To be continued]*

Ten Air Conditioning Commandments

By Willis H. Carrier*

1) Don't make rash promises about miraculous "cures" for various ailments through air conditioning. Air conditioning may help to alleviate suffering of hay fever victims, for instance, but will not cure them.

2) Don't sell inadequate equipment just to make the sale. A room cooler will not condition a large store.

3) Don't allow people to "show off" their systems by running them "40 degrees cooler than outside."

4) Don't take anything for granted in figuring or installing a system.

5) Don't stop trying to cut costs where it can be done legitimately and without affecting the efficiency.

6) Don't cease looking for new outlets and markets for air conditioning. Twenty years ago, we would never have dreamed of installing equipment in the deepest gold mine in South Africa.

7) Don't place outlets so breezes keep the boss cool and give his secretary a "pain in the neck." One person, conducting a "one man campaign against air conditioning," can do more harm than 10 satisfied customers can do good.

8) Don't fail to sell air conditioning for winter use as well as summer.

9) Don't "pinch pennies" when installing equipment and duct work. You'll save your client money in the long run through lower operating cost and satisfaction.

10) Don't take anything for granted about the public's knowledge of air conditioning. Educate the general public, wherever possible, to the advantages of true air conditioning. Progress in development of the industry can be traced to the public's insistence on equipment which performs air conditioning's full functions.

*Chairman of the Board, Carrier Corp.

Reinforcing Welded Branch Connections

By F. C. Fantz* and W. G. Hooper*

AS the result of tests, investigations and technical research of the art of welding by engineering companies and manufacturers, the quality of both the welding procedure and skill of the operators have been developed to such a degree that the piping designer has no hesitancy in using welded construction throughout his entire piping scheme regardless of pressure or temperature. This is borne out by the fact that today 100 per cent welded piping systems are general rather than exceptional. The American Society for Testing Materials, American Standards Association, American Society of Mechanical Engineers, and the American Welding Society have made available to the engineering fraternity specifications and codes governing materials, design, fabrication and construction especially suited to the various types and classes of piping design.

There is lacking, however, definite rules and formulas pertaining to the strength of welded branch connections as applied specifically to the piping industry. The ASME boiler construction code, the ASME construction code for unfired pressure vessels and the ASME-API code for unfired pressure vessels, give rules governing the attachment of nozzles to boilers, tanks, etc., but owing to the numerous types, sizes and service conditions of nozzles and shells peculiar to the boiler and tank industry, these rules are more or less complex and vague—especially to the piping designer who has not had special training or experience in boiler and tank design. It is logical to assume that if these rules which have been formulated and made mandatory by the ASME boiler codes will assure adequate safety in the reinforcement of nozzle welds, these same rules would also apply, within definite limitations, to the piping industry, to obtain safe and adequate reinforcement (if and when necessary) of welded branch connections.

Section U-59 of the ASME code for unfired pressure vessels is devoted exclusively to the subject of nozzle openings, giving specific rules as to when a nozzle requires reinforcement and, if so, how much, in order to comply with the code. To give all the details and all the steps required by U-59 to assure code compliance is too lengthy. To minimize labor in piping calculations, one basic formula was derived from a condensation of the requirements of section U-59, and was modified slightly to conform to piping peculiarities.[1]

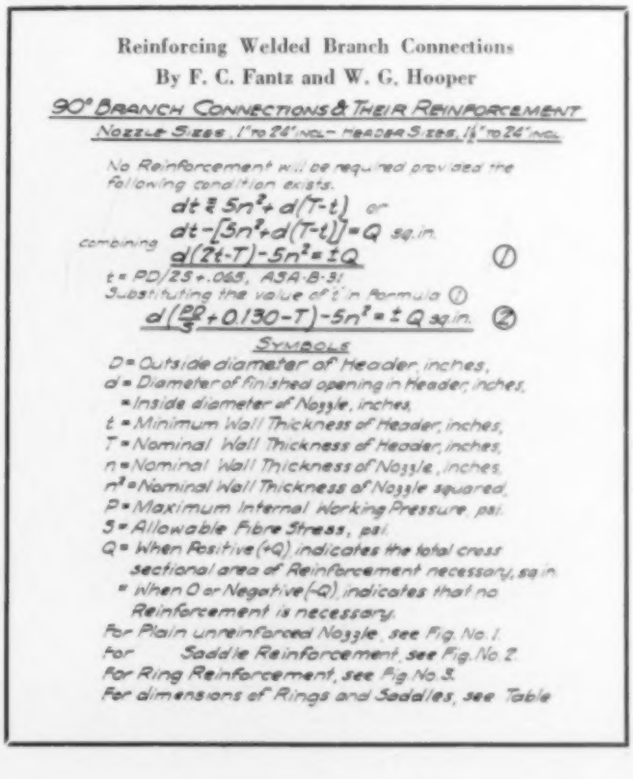
The changes made in the original formula include the elimination of the credit for a 2 in. opening in the shell for the reason that pressure loadings on test drums have indicated that failure is initiated at small holes required for test connections; the formula used for ascertaining the minimum wall thickness of the header or nozzle is that recommended by ASA code for pressure piping, $(t = PD/2S + 0.065)$. The nominal wall thickness of either the header or nozzle is based on the schedule number method (Schedule No. $= 1000 \times P/S$.)

The recommended rule applying to branch connections in sizes from 1 to 24 in. nominal pipe size, attached to headers in sizes from 1½ to 24 in. nominal pipe size, and whose angle of intersection is between 85 and 90 deg can be stated as follows: No reinforcement of the header wall will be necessary providing that the cross-sectional area of the finished opening in the header, Fig. 1, is either equal to or less than the sum of the following attachment cross-section areas—

1) The cross-sectional area of the branch connection.
2) The cross-sectional area of the attachment welds.
3) The difference in cross-sectional area of the finished opening in the header based on the nominal wall thickness and that based on the minimum wall thickness required for the stated pressure and temperature.

The cut headed "90 Deg Branch Connections and Their Reinforcement," reproduced herewith, summarizes the essential information, defines the various terms used, and gives the formula. This formula includes compensation for the fact that, according to ASTM specifications, the minimum wall thickness may be 12½ per cent less than nominal.

The foregoing discussion pertains only to the application of reinforcement to compensate for the weakening of the header due to cutting of the hole in the header wall for the nozzle; no consideration has been given to any reinforcing or strengthening of the nozzle intersection with the header. The required header reinforcement can be obtained by the use of a shaped ring, Fig. 3, or by the shaped saddle, Fig. 2.


Reinforcing Welded Branch Connections
By F. C. Fantz and W. G. Hooper
90° Branch Connections & Their Reinforcement
Nozzle Sizes, 1" to 24" incl. — Header Sizes, 1½" to 24" incl.
No Reinforcement will be required provided the following condition exists.
dt ≥ 5n² + d(T-t) or
dt - [5n² + d(T-t)] = Q sq.in.
combining
d(2t-T) - 5n² = ±Q ①
t = PD/2S + .065, ASA-B-31
Substituting the value of t in formula ①
d(PD/S + 0.130 - T) - 5n² = ±Q sq.in. ②
Symbols
D = Outside diameter of Header, inches,
d = Diameter of finished opening in Header, inches,
= Inside diameter of Nozzle, inches,
t = Minimum Wall Thickness of Header, inches,
T = Nominal Wall Thickness of Header, inches,
n = Nominal Wall Thickness of Nozzle, inches,
n² = Nominal Wall Thickness of Nozzle squared,
P = Maximum Internal Working Pressure, psi.
S = Allowable Fibre Stress, psi.
Q = When Positive (+Q), indicates the total cross sectional area of Reinforcement necessary, sq.in.
= When 0 or Negative (-Q), indicates that no Reinforcement is necessary.
For Plain unreinforced Nozzle, see Fig. No. 1.
For Saddle Reinforcement, see Fig. No. 2.
For Ring Reinforcement, see Fig. No. 3.
For dimensions of Rings and Saddles, see Table

*Vice-president, Midwest Piping and Supply Co., Inc.

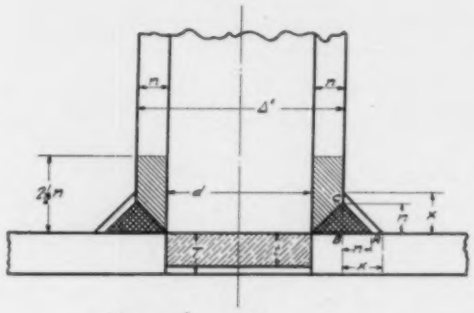
[1]See paper presented by the authors at the annual meeting of the American Welding Society, October, 1939. This paper and the discussion of it by Arthur McCutchan were reviewed in HEATING, PIPING AND AIR CONDITIONING, December, 1939, pp. 732-733.

The designer, in making his selection as to the type of reinforcement to be employed, should thoroughly investigate the conditions as to the external stresses and strains which will be imposed upon the nozzle when in actual service. There are but few instances in the average piping design where the branch connection or nozzle is not subjected to severe bending moments caused by expansion and contraction due to temperature changes. These external forces occasion maximum stresses and strains at the intersection of the nozzle with the header and frequently are sufficiently great to cause rupture. It is obvious that where such forces exist that special reinforcement must be provided to counteract these forces.

A welding saddle such as shown in Fig. 2, being accurately formed into a saddle with an integral collar closely encircling the nozzle, performs a dual service by adequately reinforcing the weakened header and by supporting the section of the branch connection. It tends to relieve the weld at the intersection of concentrated strains set up by movement of the connecting branch line caused by expansion and contraction, and by so-called hammer shocks.

PLAIN NOZZLE WELD

Fig. 1.



$$d(2t-T)-5n^2=Q \text{ sq. in.}$$

If the amount Q is relatively small, the additional reinforcing may be done by increasing the cross sectional area of the Fillet Weld ABC, and

$$Q=x\cdot x\cdot 0.50\times 2-n\cdot n\cdot 0.50\times 2$$

$$Q=x^2-n^2$$

$$x=\sqrt{Q+n^2}$$

When, in order to obtain the required reinforcement, it would necessitate the length of the sides of the Fillet Weld ABC being increased to more than 1½n, then the reinforcement must be applied by some other method, such as Ring or Saddles. See Figs. "2 & "3.

Note:

Fillet Welds used in attaching the reinforcement shall be Full fillet welds.

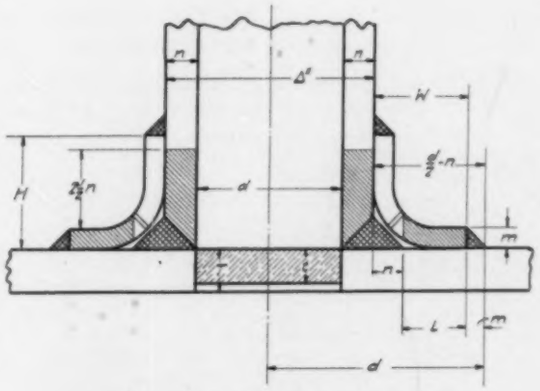
Ring and Saddle Dimensions

Nominal Wall Thickness of Header T	Minimum Thickness of Reinforcing Ring h	Nominal Nozzle Size	Reinforcing Saddle		
			Thickness m	Width W	Height H
		2	⅜	1¾	1¼
		2½	⅜	1¾	1¼
		3	⅜	2	1¼
¼ to 11/16	¼	3½	⅜	2	1¼
¾ to 15/16	5/16	4	⅜	2	2
7/8 to 1 5/16	3/8	5	⅜	2	2
1⅜ to 1⅝	7/16	6	⅜	2½	2½
1¾ to 2¼	½	8	½	3	3
2⅜	9/16	10	½	3½	3½
2½	11/16	12	½	4	4
2¾ to 3	¾	14	½	4	4
3 and over	1	16	½	4	4
		18	½	4	4
		20	½	5	5
		24	½	5	5

All dimensions are in inches.

SADDLE REINFORCEMENT

Fig. 2.



$$d(2t-T)-5n^2=Q \text{ sq. in. total area reinforcement}$$

$$Q=2\cdot L\cdot m+2\cdot m\cdot m\cdot\tfrac{1}{2}$$

$$Q=(2L+m)m, \text{ providing that } L+m+n \text{ is not greater than } \tfrac{5}{8}\text{-n.}$$

$$L=\frac{Q-m^2}{2m}, \text{ for values of m see Table}$$

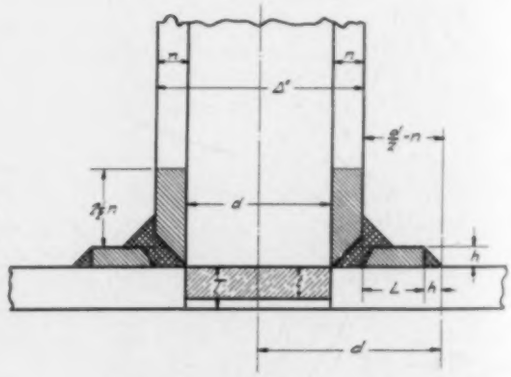
As ⅝-n is the limiting length of the reinforcement, no credit can be allowed for that portion of the reinforcing saddle and its attaching weld that may project beyond the limit ⅝-n, but 2½n can be increased to 2½n+m.

Note:

Fillet Welds used in attaching the reinforcement shall be Full Fillet Welds.

RING REINFORCEMENT

Fig. 3.



$$d(2t-T)-5n^2=Q \text{ sq. in. total area reinforcement}$$

$$Q=(2L+h)h, \text{ providing that } L+h \text{ is not greater than } \tfrac{5}{8}\text{-n.}$$

$$L=\frac{Q-h^2}{2h}, \text{ for values of h see table}$$

As ⅝-n is the limiting length of the reinforcement, no credit can be allowed for that portion of the reinforcing ring and its attaching weld that may project beyond the limit ⅝-n, but 2½n can be increased to 2½n+h.

Note:

Fillet Welds used in attaching the reinforcement, shall be Full Fillet Welds.

Unit Heaters Prevent Cold Drafts at Building and Store Entrances

By D. R. Rippey*

A unit heater installed in a box beside the revolving door solved the problem in a restaurant

ONE of the toughest problems that confronts the operating engineer or building manager is eliminating drafty conditions near entrances. In most cases, the situation is never taken seriously until such time as conditions become more or less unbearable —generally long after the installation of the entrance has been completed and the builders have departed. No doubt, most such entrances are completed during the time of the year when heat is not a factor, and there seems to be a feeling among most people that with the installation of a revolving door, heating problems vanish —with the result it is often necessary to make additional changes in the structure to accommodate necessary heating equipment.

Restaurant a Difficult Problem

One of the hardest occupancies to care for in the way of uniform temperature is the restaurant. In the first place, it is necessary that a considerable amount of air be exhausted from the kitchen, which means that in many cases the supply air to satisfy the exhaust is taken through the dining room; this in turn means that it enters through the door openings. During the usual meal times (especially during the luncheon period) all seats are taken, and those nearest the door, which during slack times of the day are vacant, are in use. At the same time, the traffic through the entrance doors is many times heavier than average at the time these near-the-door seats are occupied, with the result that in addition to the chilly feeling one experiences while sitting near to the entrance, there is a cold blast of air across the floor every time someone enters.

Using as an illustration a prominent restaurant in Chicago, we found on an average winter day with a slight wind blowing that from a point of entry at the revolving door there was a radius of approximately 20 ft which was considerably below the average room temperature between the hours of 11:00 a. m. and 2:00 p. m. The same condition existed during the dinner hour, but the area was diminished somewhat during the breakfast period due to lighter traffic. In the cold area involved, there are seats for approximately 14 people, and with the coming of cold weather the proprietor noticed with regret that these chairs generally were vacant. When some unsuspecting soul would sit down there to enjoy

*Resident Manager, Tower Building, Chicago, Ill.

Unit Heaters Prevent Cold Drafts at Building and Store Entrances
By D. R. Rippey

One of the toughest problems that confronts the engineer or building manager is eliminating drafty conditions around entrances in restaurants, stores and building lobbies. In stores and restaurants, the tenant wants to use every square foot of available space for which he is paying and does not want otherwise usable space made uncomfortable because of cold air rushing in through the doors. In a store, too, fixtures are often crowded in so that the heating surface is effectively blocked off—this complicates the problem . . . . . Unit heaters may be used for solving this heating problem, as shown by several examples given here. In a restaurant, for instance, a unit with a three speed motor to give some measure of control installed in a box on the floor along side the revolving door allows use of the tables near the door which were formerly uncomfortable. In a retail store a unit heater can often be set in a bulkhead with the louvers vertical and turned to discharge warm air toward the door opening . . . . . For heating the entrance in a building lobby, units may be placed near the floor on both sides of the door . . . . . The idea of such installations is to temper the cold entering air with warm air from the unit. Three speeds are desirable to prevent overheating in the milder weather. Such units should be protected from the public—if they are near the floor—by an enclosure which should have a grille for access to the unit and to allow air to enter it . . . . . Most of what we know about unit heaters comes from experience. Readers are invited to send in examples of how they have used units to heat entrances, gyms, auditoriums, libraries, churches, etc. Those contributions that can be published will be paid for at regular rates

his meal, he was apt to leave in a bitter frame of mind.

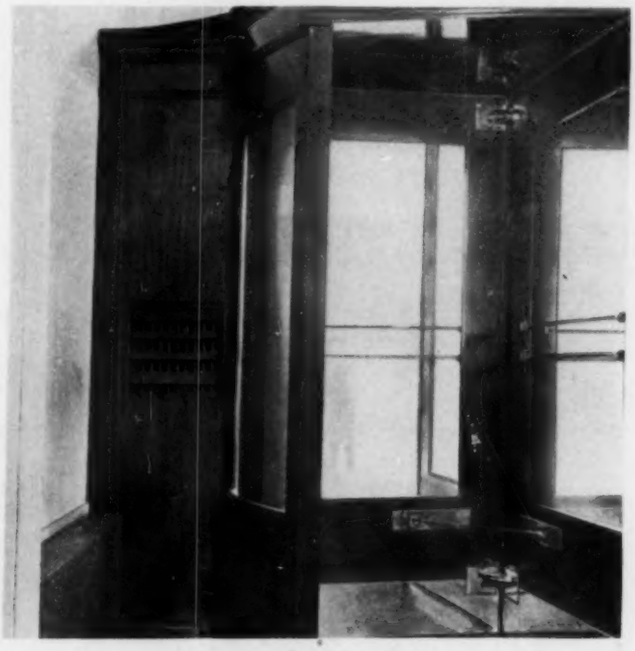
Upon investigating the difficulty, it was discovered that the cold area was that stratum very close to 2 ft from the floor. It was found that it was absolutely necessary to catch the incoming cold air before it had a chance to roll across the floor to the nearest tables. At the same time we were stopping the cold air from hitting the customers, it was also necessary to refrain from blasting these people with a wave of hot air.

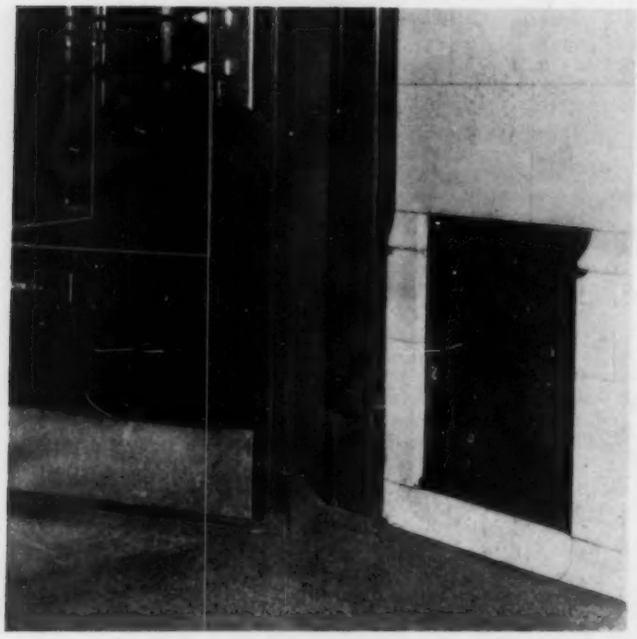
We therefore installed a unit heater with a three speed motor on the floor immediately adjacent to the revolving door frame at an angle which would allow the hot air from the unit heater to intercept the entering cold air (see picture). We selected a unit in this particular instance with a capacity of 130 sq ft of equivalent direct radiation, a maximum air delivery of 353 cfm, and an outlet velocity of 425 ft. We used the three speed arrangement in order to keep in closer step with the weather conditions, as oftentimes the low speed is quite adequate and this tends to eliminate the possibility of intense overheating in the vicinity of the entrance, as would be the case with a single speed motor with a capacity to care for extreme conditions. The 130 sq ft capacity is somewhat higher than is absolutely necessary; however, the additional cost between that unit and the smaller one was so little that we thought it best to stretch the capacity somewhat and be sure of having plenty.

It is necessary in an installation of this kind to protect the unit from the public, so a wooden housing was built around it with a grilled opening in the back. No attempt was made to pull the incoming cold air through the unit heater; the idea is to temper this air with the warm air from the unit.

Since installation of this unit, the area which is uncomfortable because of cold air has been reduced to that within 6 ft of the entrance. The installation has been in use through an outside temperature range of from sub-zero to 50 deg above and recording thermometer tests show satisfactory temperatures at the previous cold spots.

Unit heaters on both sides of the entrance to a building lobby are effective in improving heating of this space





Heating Building Lobbies

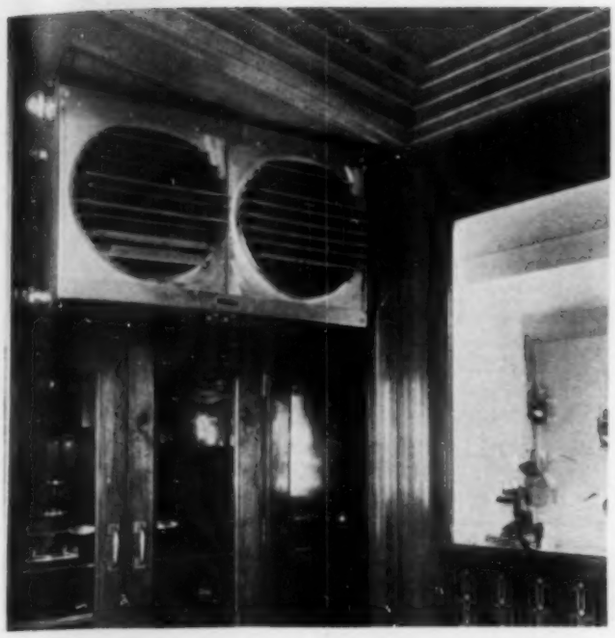
We all know that it is not necessary to maintain as high a temperature in the building lobby as in the balance of the building; however, it is necessary to keep the lobby warm enough to prevent discomfort when entering it from the elevators or adjoining stores.

Two of the accompanying pictures illustrate a good way to heat the entering air in a building lobby by situating the unit heaters near the floor on both sides of the entrance. These units have a capacity of approximately 100 sq ft EDR and have three speed motors. Wherever at all possible, the steam for unit heaters should be at a constant pressure to eliminate the blowing of hot and then cold air. It is best to keep them independent of the general heating system.

Retail Stores Hard to Heat

Retail stores are very difficult to heat, because (as we all know) the tenant is paying for floor space and wants every available foot occupied by trade fixtures, including that space ordinarily intended for radiators. Those radiators which are allowed to stay, after much persuasion by the engineer, are often very carefully covered up—apparently so that no stray Btu will be found wandering around the room. When the winter winds begin to blow the building office may get a call to this effect: "This is Miss Knowitall, of the Wearem-Shorter Dress Shop; we've been freezing down here for two whole days. Whatsamatter with your engineer? My customers can't even try on a dress. We've never been this cold before. We want something done about it." Bang goes the receiver! (I might mention at this point that an engineer's hair is not gray from operating his plant—almost all diplomats have gray hair).

Most of the smaller retail stores have swing doors and



Unit heaters of this type are installed in the seven lobbies of the large May department store, Cleveland. The entrance heating problem is an acute one, as an open public square makes the exposure severe. Warm air is blown toward the outer swing doors of the entry

considerable cold air enters every time the door opens. Due to the fixture layout in these stores it is usually next to impossible to place a unit heater so as to discharge directly against the incoming air. However, oftentimes a unit heater can be set into the bulkhead with the louvers vertical and turned to discharge toward the door opening. A grille that will act as an access panel and air supply to the unit must be provided.

Where a unit cannot be placed near the floor, it can usually be set above the entrance, discharging out into the room. This method does not take care of the floor area in the vicinity of the door, but will care for the general heating of the store.

Most of what you and I know about the application of unit heaters comes from our experiences and those of the manufacturers. So as long as we expect to be using unit heaters in many ways, why not send in your ideas and experiences on their various applications? How about capacities for intermittent heating of gyms and auditoriums, for instance, the quietness and location of those for libraries and churches, other ways in which building and store entrances are successfully heated, etc.? Give us your ideas—when possible to publish them they will be paid for at regular rates.

Should Hospital Operating Room Air Be Recirculated?

Is the introduction of 100 per cent outdoor air considered to be imperative when air conditioning hospital operating rooms?, asks a reader of HPAC. The following reply was prepared in answer to his question:

According to Dr. Murray B. Ferderber of the school of medicine of the University of Pittsburgh, the question is rather difficult to answer in its entirety. However, he feels that it is necessary to have 100 per cent outside air for conditioning an operating room because recirculation may build up not only odors but the concentration of anesthetic gases, which would be quite dangerous. In the Magee Hospital operating room, the recovery room adjacent to the operating room uses only 50 per cent outside air.

Recirculation would be less expensive, says Dr. Ferderber, but the accumulation of any pathological organisms may be the means of spreading infection to other portions of the institution. Wells has demonstrated that organisms can be transported and Dr. Ferderber accepts his findings as indicating the need for preventing infections. Individual room coolers could certainly be used for air conditioning operating rooms, according to Dr. Ferderber, but he emphasizes that where mixtures of air from contagious or infectious cases might cause sufficient difficulty, only the use of outside air would be warranted. This holds true for conditioning infants' nurseries, operating rooms and contagious wards. Unfortunately, says Dr. Ferderber, there is no guarantee that a patient admitted to a hospital for a purely surgical condition might not be in the incubative stage of a contagious infection. Therefore, Dr. Ferderber concludes that from his knowledge the only exceptions to using 100 per cent outside air are the recovery wards (non-infected), resident's wards (non-infected) and private rooms.

L. R. Flook, Superintendent of Buildings and Grounds, University of Chicago, says that although their operating room system has provisions for recirculation, they do not recirculate the air but use 100 per cent outside air. Anesthetic gases are piped to these rooms and the staff likes to feel that all of the air introduced to the rooms is from the outside and is exhausted to the outside and not re-used. Some of these gases are, of course, of an inflammable or explosive nature. Relative humidities of 55 to 60 per cent are maintained to prevent the hazard of static electricity sparks.

The Heating, Ventilating, Air Conditioning Guide of the American Society of Heating and Ventilating Engineers states that copious ventilation, from six to twelve air changes per hour, is necessary to preclude accumulations of explosive mixtures and reduce the concentration of anesthetics below the physiologic threshold so that the surgeons and personnel will not be affected. The Guide also states that air conditioning systems should operate without recirculation during anesthesia.

Charles F. Neergaard, hospital consultant, advises that in operating and delivery rooms he always recommends 100 per cent outside air, although in nurseries and patients' rooms and wards a certain amount of recirculated air is permissible. However, this is for rooms where individual room units are used.

In Mr. Neergaard's judgment, it is unsound practice to recirculate air between rooms and wards because there is a danger of carrying cross infection. In the present stage of the development of central air conditioning, Mr. Neergaard says, he does not feel that it is economically sound to air condition an entire hospital. He says that as a rule he makes provision for air conditioning operating rooms, delivery rooms and nurseries from a central compressor, with individual units of the portable type for the rooms where patients require or can afford the extra charge for them.

How a Duct Is Designed

THERE has been considerable discussion among several readers of HPAC as to the correct design for an air duct, a subscriber in the engineering department of an industrial plant writes. Consider, (he says), that a fan is delivering a quantity Q of air to a horizontal rectangular wooden duct of 100 ft length. It is desired that this air be blown out of equal sized uniformly spaced nozzles along the entire base of the duct. The velocity out of each nozzle should be constant and equal to 1000 fpm. How, he asks, should the duct be designed?

REPLY BY SAMUEL R. LEWIS*—There are two recognized methods of designing ducts: (a) For uniform air velocity throughout their length. (b) For uniform pressure drop per foot of length.

Method (b) is the scheme employed by most designers since it can be used usually with greater facility. With either method, the air velocities employed must lie within certain reasonable limits to obtain noise control, avoidance of vibration in the duct structure, etc. These limits have been established through experience and should be applied with judgment.

Both methods are illustrated with the following examples, using the data suggested above and completed with certain necessary assumptions:

Constant Velocity Method—It is assumed that five outlets, each delivering 2000 cfm, are required. Assume that a uniform velocity of 1000 fpm shall be employed. The steps shown in Table 1 are taken in order.

Table 1—Example of Constant Velocity Method

	Sec. A	Sec. B	Sec. C	Sec. D	Sec. E	Total Frictional Resistance of Duct
Cfm per section	10000	8000	6000	4000	2000	
Area required, sq ft	10	8	6	4	2	
Duct size selected	40x36	32x36	24x36	24x24	24x12	
Equivalent round duct diam., in	41.7	37.3	32.2	26.4	18.5	
Friction loss per 100 ft, in. of water	0.035	0.042	0.052	0.07	0.1	
Friction loss per 20 ft length of section, in. water	0.007	0.0084	0.0104	0.014	0.02	0.0598
Or, if duct size selected should be	60x24	48x24	36x24	24x24	24x12	
Equivalent round duct diam., in	40.9	37.0	32.2	26.4	18.5	
Friction loss per 100 ft, in. of water	0.04	0.045	0.052	0.07	0.1	
Friction loss per 20 ft length of section, in. water	0.008	0.009	0.0104	0.014	0.02	0.0614

Constant Pressure Drop Method — Utilizing the standard air friction chart, selecting the uniform resistance of 0.05 in. per 100 ft duct as being within the limits of allowable total pressure drop of the duct system and of allowable air velocities, the steps following are taken in chronological order in Table 2.

Table 2—Example of Constant Pressure Drop Method

	Sec. A	Sec. B	Sec. C	Sec. D	Sec. E
Equivalent round duct diam., in	39.2	36.	32.6	28	21.8
Duct size selected a	55x24	46x24	37x24	27x24	22x18

*Selected from a table of equivalent duct sizes for equal resistance.

*Consulting Mechanical Engineer. Member of Board of Consulting and Contributing Editors.

How a Duct Is Designed
(Answer to a Reader's Question)

There has been considerable discussion among several readers of HPAC as to the correct design for an air duct, writes a subscriber who asks how to go about designing a horizontal rectangular wooden duct . . . . . Samuel R. Lewis answers his question here. There are two recognized methods for designing ducts: (a) For uniform air velocity throughout their entire length; and (b) for uniform pressure drop per foot of length. Each of these methods is used in an example, the values for friction and equivalent duct sizes being read from the chart and table in the Heating, Ventilating, Air Conditioning Guide . . . . . Factors for ducts of various materials are given

The total resistance of the duct system then is equivalent to 0.05 in. per 100 ft $\times$ 100 ft = 0.05 in.

The chart and table referred to are published in the Heating, Ventilating, Air Conditioning Guide of the American Society of Heating and Ventilating Engineers, and may be found in most standard texts and handbooks dealing with the subject of ventilating.

These examples are developed by the use of the standard air friction chart for average construction of galvanized steel ducts. For ducts of other material or construction the following factors are applied to the resistances thus determined.

Material	*Factor*
Perfectly smooth drawn tubing of metal or glass	0.8
For smooth, straight galvanized steel ducts	0.9
For smooth concrete, wood, or light riveted sheet steel ducts	1.1
For good brick, rough concrete, heavy riveted or spiral riveted sheet steel ducts	1.2

For a wood duct, therefore, the resistances as determined in the above examples would be, respectively:

1.1 $\times$ 0.0598	0.06578 in.
1.1 $\times$ 0.0614	0.06754 in.
1.1 $\times$ 0.05	0.055 in.

A Method for Approximating the Steam Required for Heating Water

In determining the amount of steam for heating a building it is often necessary to make an estimate of the steam used for heating domestic service water. This is then subtracted from the total steam used, the remainder being the steam for building heating.

According to Rex E. Hieronymus, General Superintendent of Aldis & Co. (who manage 20 Chicago buildings), the following method of estimating amount of steam for heating domestic service water in office buildings checks out quite accurately: The steam for heating service water for the months of June, July and August is totalled, and this figure is equal to 21 per cent of the annual steam requirement for water heating. This method was formulated by the Illinois Maintenance Co. and has been found to apply where the yearly degree days are around 6000, and where the water supply is from open bodies of water (not wells).

Properties of Mixtures of Air and Saturated Water Vapor for Barometric Pressures from 22 In. to 32 In. of Mercury

By William Goodman*

Barometric Pressure 29 In. of Mercury

All tabulated values (except temperatures and pressures) are quantities per pound of dry air in the mixture.

Temp Deg Fahr	Absolute Humidity		Volume		Humid Specific Heat	1061w	Enthalpy (Heat Content)	
	Pounds	Grains	Dry Air Cu Ft	Volume Increase of Humid Air Per Cent			Water Vapor Btu	Air-Vapor Mixture Btu
t	w	w	v_D		s''		h_V	h
1	2	3	4	5	6	7	8	9
−40	0.0001201	0.8405	10.91	0.01930	0.2401	0.1274	0.1252	−9.475
−39	.0001271	0.8897	10.94	.02043	.2401	.1349	.1326	−9.227
−38	.0001347	0.9426	10.97	.02165	.2401	.1429	.1406	−8.979
−37	.0001426	0.9980	10.99	.02292	.2401	.1513	.1489	−8.731
−36	.0001509	1.056	11.02	.02426	.2401	.1601	.1577	−8.482
−35	0.0001596	1.117	11.04	0.02565	0.2401	0.1693	0.1668	−8.233
−34	.0001689	1.182	11.07	.02715	.2401	.1792	.1766	−7.983
−33	.0001785	1.250	11.10	.02870	.2401	.1894	.1868	−7.733
−32	.0001888	1.322	11.12	.03035	.2401	.2003	.1976	−7.482
−31	.0001994	1.396	11.15	.03205	.2401	.2115	.2088	−7.231
−30	0.0002108	1.475	11.18	0.03389	0.2401	0.2236	0.2208	−6.979
−29	.0002226	1.558	11.20	.03579	.2401	.2362	.2333	−6.727
−28	.0002349	1.644	11.23	.03776	.2401	.2492	.2462	−6.474
−27	.0002480	1.736	11.25	.03988	.2401	.2632	.2602	−6.220
−26	.0002617	1.832	11.28	.04207	.2401	.2776	.2746	−5.966
−25	0.0002760	1.932	11.31	0.04437	0.2401	0.2928	0.2897	−5.710
−24	.0002911	2.038	11.33	.04680	.2401	.3089	.3057	−5.454
−23	.0003071	2.149	11.36	.04936	.2401	.3258	.3226	−5.197
−22	.0003235	2.265	11.38	.05202	.2402	.3433	.3401	−4.940
−21	.0003409	2.386	11.41	.05481	.2402	.3617	.3585	−4.682
−20	0.0003592	2.515	11.44	0.05775	0.2402	0.3811	0.3779	−4.422
−19	.0003784	2.649	11.46	.06084	.2402	.4015	.3983	−4.162
−18	.0003983	2.788	11.49	.06403	.2402	.4226	.4194	−3.901
−17	.0004192	2.934	11.51	.06739	.2402	.4448	.4416	−3.638
−16	.0004414	3.090	11.54	.07096	.2402	.4683	.4651	−3.375
−15	0.0004641	3.249	11.57	0.07461	0.2402	0.4924	0.4893	−3.111
−14	.0004882	3.417	11.59	.07849	.2402	.5180	.5149	−2.845
−13	.0005135	3.595	11.62	.08156	.2402	.5449	.5419	−2.578
−12	.0005398	3.779	11.64	.08678	.2402	.5727	.5698	−2.310
−11	.0005669	3.968	11.67	.09114	.2403	.6015	.5987	−2.041
−10	0.0005962	4.174	11.70	0.09586	0.2403	0.6326	0.6299	−1.770
−9	.0006260	4.382	11.72	.1006	.2403	.6642	.6617	−1.498
−8	.0006579	4.605	11.75	.1058	.2403	.6980	.6957	−1.224
−7	.0006903	4.832	11.77	.1110	.2403	.7324	.7303	−0.9498
−6	.0007244	5.071	11.80	.1165	.2403	.7686	.7667	−0.6733
−5	0.0007608	5.325	11.83	0.1223	0.2403	0.8072	0.8055	−0.3945
−4	.0007980	5.586	11.85	.1283	.2404	.8467	.8452	−0.1148
−3	.0008370	5.859	11.88	.1346	.2404	.8880	.8869	+0.1669
−2	.0008781	6.147	11.90	.1412	.2404	.9317	.9309	0.4509
−1	.0009210	6.447	11.93	.1481	.2404	.9772	.9768	0.7368
0	0.0009648	6.754	11.96	0.1551	0.2404	1.024	1.024	1.024
1	.001011	7.076	11.98	.1625	.2405	1.073	1.073	1.313
2	.001059	7.413	12.01	.1703	.2405	1.124	1.125	1.605
3	.001109	7.766	12.03	.1784	.2405	1.177	1.179	1.899
4	.001162	8.137	12.06	.1869	.2405	1.233	1.235	2.195
5	0.001217	8.518	12.09	0.1956	0.2406	1.291	1.294	2.494
6	.001273	8.914	12.11	.2047	.2406	1.351	1.355	2.795
7	.001333	9.328	12.14	.2142	.2406	1.414	1.418	3.098
8	.001394	9.761	12.16	.2242	.2406	1.480	1.485	3.405
9	.001459	10.22	12.19	.2346	.2407	1.548	1.554	3.714
10	0.001526	10.68	12.22	0.2453	0.2407	1.619	1.626	4.026
11	.001597	11.18	12.24	.2567	.2407	1.694	1.702	4.342
12	.001669	11.68	12.27	.2683	.2408	1.771	1.780	4.660
13	.001743	12.20	12.29	.2802	.2408	1.849	1.860	4.980
14	.001823	12.76	12.32	.2931	.2408	1.934	1.946	5.306
15	0.001905	13.34	12.35	0.3063	0.2409	2.021	2.034	5.634
16	.001989	13.93	12.37	.3198	.2409	2.111	2.125	5.965
17	.002077	14.54	12.40	.3340	.2409	2.204	2.220	6.300
18	.002169	15.18	12.42	.3487	.2410	2.301	2.319	6.639
19	.002265	15.86	12.45	.3641	.2410	2.403	2.423	6.983
20	0.002363	16.54	12.48	0.3799	0.2411	2.507	2.529	7.329
21	.002468	17.27	12.50	.3967	.2411	2.618	2.642	7.682
22	.002574	18.02	12.53	.4137	.2412	2.731	2.756	8.036
23	.002685	18.79	12.55	.4316	.2412	2.849	2.877	8.397
24	.002800	19.60	12.58	.4502	.2413	2.971	3.002	8.762
25	0.002918	20.43	12.61	0.4692	0.2413	3.096	3.129	9.129
26	.003045	21.31	12.63	.4895	.2414	3.230	3.266	9.506
27	.003172	22.21	12.66	.5100	.2414	3.366	3.405	9.885
28	.003306	23.14	12.68	.5315	.2415	3.507	3.549	10.27
29	.003445	24.11	12.71	.5538	.2416	3.655	3.700	10.66
30	0.003589	25.12	12.74	0.5770	0.2416	3.808	3.857	11.06
31	.003740	26.18	12.76	.6013	.2417	3.969	4.021	11.46
32	.003892	27.25	12.79	.6256	.2418	4.130	4.187	11.87
33	.004056	28.39	12.81	.6519	.2418	4.303	4.365	12.29
34	.004223	29.56	12.84	.6788	.2419	4.481	4.547	12.71
35	0.004396	30.77	12.87	0.7066	0.2420	4.664	4.735	13.14
36	.004577	32.04	12.89	.7357	.2421	4.856	4.932	13.57
37	.004764	33.35	12.92	.7655	.2421	5.055	5.136	14.02
38	.004957	34.70	12.94	.7967	.2422	5.259	5.345	14.47
39	.005157	36.10	12.97	.8286	.2423	5.471	5.563	14.92

Temp Deg Fahr	Absolute Humidity		Volume		Humid Specific Heat	1061w	Enthalpy (Heat Content)	
	Pounds	Grains	Dry Air Cu Ft	Volume Increase of Humid Air Per Cent			Water Vapor Btu	Air-Vapor Mixture Btu
t	w	w	v_D		s''		h_V	h
1	2	3	4	5	6	7	8	9
40	0.005364	37.55	13.00	0.8619	0.2424	5.691	5.789	15.39
41	.005577	39.04	13.02	0.8963	.2425	5.917	6.021	15.86
42	.005799	40.59	13.05	0.9318	.2426	6.153	6.264	16.34
43	.006028	42.19	13.07	0.9687	.2427	6.395	6.513	16.83
44	.006265	43.85	13.10	1.007	.2428	6.647	6.772	17.33
45	0.006514	45.60	13.13	1.047	0.2429	6.911	7.044	17.84
46	.006769	47.38	13.15	1.088	.2431	7.181	7.323	18.36
47	.007031	49.22	13.18	1.130	.2432	7.460	7.611	18.89
48	.007305	51.13	13.20	1.174	.2433	7.750	7.909	19.43
49	.007587	53.11	13.23	1.219	.2434	8.050	8.218	19.98
50	0.007881	55.17	13.26	1.266	0.2436	8.362	8.541	20.54
51	.008186	57.30	13.28	1.315	.2437	8.685	8.874	21.11
52	.008494	59.46	13.31	1.365	.2438	9.012	9.212	21.69
53	.008822	61.76	13.33	1.417	.2440	9.360	9.572	22.29
54	.009153	64.07	13.36	1.471	.2441	9.711	9.935	22.90
55	0.009498	66.49	13.39	1.526	0.2443	10.08	10.31	23.51
56	.009857	69.00	13.41	1.583	.2444	10.46	10.71	24.15
57	.01022	71.46	13.44	1.643	.2446	10.85	11.11	24.79
58	.01061	74.26	13.46	1.704	.2448	11.26	11.53	25.45
59	.01100	76.99	13.49	1.767	.2450	11.67	11.96	26.12
60	0.01140	79.71	13.52	1.832	0.2451	12.10	12.41	26.81
61	.01182	82.77	13.54	1.900	.2453	12.55	12.87	27.51
62	.01227	85.86	13.57	1.969	.2455	13.01	13.36	28.24
63	.01271	88.99	13.59	2.042	.2457	13.49	13.85	28.97
64	.01317	92.18	13.62	2.116	.2459	13.97	14.35	29.71
65	0.01366	95.59	13.65	2.192	0.2462	14.49	14.89	30.49
66	.01414	99.00	13.67	2.272	.2464	15.01	15.42	31.27
67	.01466	102.6	13.70	2.354	.2466	15.55	15.99	32.07
68	.01518	106.3	13.72	2.438	.2468	16.11	16.57	32.89
69	.01573	110.1	13.75	2.525	.2471	16.68	17.17	33.73
70	0.01629	114.0	13.78	2.616	0.2473	17.28	17.79	34.59
71	.01686	118.1	13.80	2.708	.2476	17.89	18.43	35.47
72	.01747	122.3	13.83	2.805	.2479	18.53	19.09	36.37
73	.01807	126.5	13.85	2.904	.2481	19.18	19.77	37.29
74	.01872	131.0	13.88	3.006	.2484	19.86	20.48	38.24
75	0.01937	135.6	13.91	3.111	0.2487	20.55	21.20	39.20
76	.02005	140.3	13.93	3.219	.2490	21.27	21.95	40.19
77	.02076	145.3	13.96	3.333	.2493	22.03	22.74	41.22
78	.02148	150.4	13.98	3.448	.2497	22.79	23.54	42.26
79	.02222	155.5	14.01	3.568	.2500	23.58	24.36	43.32
80	0.02299	160.9	14.04	3.690	0.2503	24.39	25.21	44.41
81	.02378	166.5	14.06	3.818	.2507	25.23	26.09	45.53
82	.02460	172.2	14.09	3.948	.2511	26.10	27.00	46.68
83	.02544	178.1	14.11	4.084	.2515	27.00	27.93	47.85
84	.02630	184.1	14.14	4.222	.2518	27.91	28.89	49.05
85	0.02720	190.4	14.17	4.366	0.2522	28.86	29.89	50.29
86	.02813	196.9	14.19	4.514	.2527	29.84	30.92	51.56
87	.02908	203.6	14.22	4.667	.2531	30.85	31.98	52.86
88	.03006	210.4	14.24	4.824	.2535	31.89	33.06	54.18
89	.03108	217.5	14.27	4.987	.2540	32.97	34.20	55.56
90	0.03212	224.8	14.30	5.154	0.2545	34.08	35.36	56.96
91	.03320	232.4	14.32	5.328	.2549	35.23	36.57	58.41
92	.03430	240.1	14.35	5.504	.2554	36.39	37.79	59.87
93	.03545	248.2	14.37	5.688	.2560	37.61	39.07	61.39
94	.03663	256.4	14.40	5.877	.2565	38.87	40.39	62.95
95	0.03785	264.9	14.43	6.072	0.2570	40.15	41.75	64.55
96	.03909	273.7	14.45	6.272	.2576	41.48	43.14	66.18
97	.04038	282.7	14.48	6.478	.2582	42.84	44.57	67.85
98	.04172	292.1	14.50	6.693	.2588	44.27	46.08	69.60
99	.04310	301.7	14.53	6.914	.2594	45.73	47.61	71.37
100	0.04450	311.5	14.56	7.139	0.2600	47.22	49.19	73.19
101	.04596	321.8	14.58	7.373	.2607	48.77	50.82	75.06
102	.04747	332.3	14.61	7.614	.2614	50.37	52.51	76.99
103	.04903	343.2	14.63	7.861	.2621	52.02	54.25	78.97
104	.05063	354.4	14.66	8.119	.2628	53.72	56.04	81.00
105	0.05226	365.9	14.69	8.382	0.2635	55.45	57.87	83.07
106	.05396	377.8	14.71	8.655	.2643	57.26	59.78	85.22
107	.05573	390.1	14.74	8.935	.2651	59.13	61.76	87.44
108	.05753	402.7	14.76	9.225	.2659	61.04	63.78	89.70
109	.05940	415.8	14.79	9.522	.2667	63.02	65.87	92.03
110	0.06132	429.2	14.82	9.832	0.2676	65.06	68.03	94.43
111	.06328	443.0	14.84	10.15	.2685	67.14	70.24	96.88
112	.06533	457.3	14.87	10.47	.2694	69.32	72.54	99.42
113	.06745	472.1	14.89	10.81	.2704	71.56	74.91	102.03
114	.06962	487.4	14.92	11.16	.2713	73.87	77.36	104.72
115	0.07186	503.0	14.95	11.51	0.2723	76.24	79.88	107.48
116	.07419	519.3	14.97	11.89	.2734	78.71	82.49	110.33
117	.07657	536.0	15.00	12.27	.2745	81.24	85.18	113.26
118	.07902	553.1	15.02	12.66	.2756	83.84	87.93	116.25
119	.08153	570.7	15.05	13.07	.2767	86.50	90.76	119.32

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Properties of Mixtures of Air and Saturated Water Vapor—(Continued)
Barometric Pressure 29 In. of Mercury

All tabulated values (except temperatures and pressures) are quantities per pound of dry air in the mixture.

Temp Deg Fahr	Absolute Humidity		Volume		Humid Specific Heat	1061w	Enthalpy (Heat Content)	
	Pounds	Grains	Dry Air Cu Ft	Volume Increase of Humid Air Per Cent			Water Vapor Btu	Air-Vapor Mixture Btu
t	w	w	v_D		s''		h_V	h
1	2	3	4	5	6	7	8	9
120	0.08417	589.2	15.08	13.49	0.2779	89.30	93.74	122.54
121	.08688	608.2	15.10	13.92	.2791	92.18	96.78	125.82
122	.08963	627.4	15.13	14.36	.2803	95.10	99.89	129.17
123	.09252	647.7	15.15	14.82	.2816	98.17	103.15	132.67
124	.09548	668.4	15.18	15.30	.2830	101.31	106.49	136.25
125	0.09856	689.9	15.21	15.78	0.2844	104.57	109.97	139.97
126	.1017	712.1	15.23	16.29	.2858	107.94	113.55	143.79
127	.1050	735.1	15.26	16.81	.2873	111.42	117.25	147.73
128	.1084	758.7	15.28	17.36	.2888	114.99	121.06	151.78
129	.1119	783.1	15.31	17.92	.2903	118.69	125.00	155.96
130	0.1155	808.8	15.34	18.49	0.2920	122.59	129.16	160.36
131	.1193	834.9	15.36	19.09	.2937	126.55	133.38	164.82
132	.1230	861.1	15.39	19.70	.2954	130.52	137.62	169.30
133	.1270	889.3	15.41	20.33	.2972	134.79	142.17	174.09
134	.1312	918.3	15.44	20.99	.2990	139.18	146.86	179.02
135	0.1354	947.8	15.47	21.68	0.3009	143.66	151.63	184.03
136	.1398	978.5	15.49	22.37	.3029	148.32	156.61	189.25
137	.1444	1010.6	15.52	23.10	.3050	153.18	161.81	194.69
138	.1492	1044.1	15.54	23.86	.3071	158.25	167.23	200.35
139	.1540	1078.0	15.57	24.63	.3093	163.39	172.73	206.09
140	0.1590	1113.3	15.60	25.44	0.3116	168.74	178.44	212.04
141	.1642	1149.5	15.62	26.27	.3139	174.24	184.32	218.16
142	.1697	1188.2	15.65	27.14	.3164	180.09	190.58	224.66
143	.1753	1226.9	15.67	28.04	.3189	185.96	196.86	231.18
144	.1811	1267.5	15.70	28.96	.3215	192.12	203.46	238.02
145	0.1871	1309.8	15.73	29.93	0.3242	198.52	210.33	245.13
146	.1935	1354.2	15.75	30.93	.3271	205.26	217.55	252.59
147	.2000	1399.7	15.78	31.96	.3300	212.15	224.92	260.20
148	.2067	1447.0	15.80	33.04	.3330	219.33	232.62	268.14
149	.2137	1495.8	15.83	34.15	.3361	226.73	240.55	276.31
150	0.2211	1547.4	15.86	35.32	0.3395	234.53	248.92	284.92
151	.2286	1600.3	15.88	36.53	.3429	242.57	257.54	293.78
152	.2362	1653.6	15.91	37.78	.3463	250.64	266.21	302.69
153	.2447	1712.8	15.93	39.09	.3501	259.62	275.84	312.56
154	.2532	1772.5	15.96	40.44	.3539	268.66	285.55	322.51
155	0.2621	1835.0	15.99	41.86	0.3580	278.13	295.72	332.92
156	.2714	1899.7	16.01	43.34	.3621	287.93	306.28	343.72
157	.2809	1966.6	16.04	44.86	.3664	298.08	317.18	354.86
158	.2910	2037.3	16.06	46.47	.3710	308.79	328.70	366.62
159	.3015	2110.6	16.09	48.13	.3757	319.90	340.65	378.81

Temp Deg Fahr	Absolute Humidity		Volume		Humid Specific Heat	1061w	Enthalpy (Heat Content)	
	Pounds	Grains	Dry Air Cu Ft	Volume Increase of Humid Air Per Cent			Water Vapor Btu	Air-Vapor Mixture Btu
t	w	w	v_D		s''		h_V	h
1	2	3	4	5	6	7	8	9
160	0.3125	2187.4	16.12	49.88	0.3806	331.55	353.18	391.58
161	.3239	2267.5	16.14	51.70	.3858	343.69	366.24	404.88
162	.3360	2351.7	16 17	53.61	.3912	356.44	379.96	418.84
163	.3485	2439.2	16.19	55.60	.3968	369.72	394.25	433.37
164	.3616	2531.3	16.22	57.70	.4027	383.67	409.27	448.63
165	0.3754	2627.6	16.25	59.88	0.4089	398.27	424.99	464.59
166	.3899	2729.2	16.27	62.19	.4155	413.66	441.58	481.42
167	.4050	2835.1	16.30	64.60	.4223	429.73	458.89	498.97
168	.4211	2947.4	16.32	67.14	.4295	446.74	477.23	517.55
169	.4378	3064.5	16.35	69.80	.4370	464.48	496.36	536.92
170	0.4555	3188.3	16.38	72.61	0.4450	483.25	516.59	557.39
171	.4741	3318.4	16.40	75.56	.4533	502.98	537.87	578.91
172	.4938	3456.4	16.43	78.69	.4622	523.89	560.43	601.71
173	.5147	3602.7	16 45	82.02	.4716	546.06	584.36	625.88
174	.5367	3757.0	16 48	85.52	.4815	569.45	609.60	651.36
175	0.5598	3918.7	16.51	89.18	0.4919	593.96	636.06	678.06
176	.5845	4091.6	16.53	93.10	.5030	620.17	664.35	706.59
177	.6108	4275.5	16.56	97.29	.5149	648.04	694.46	736.94
178	.6386	4470.5	16.58	101.7	.5274	677.60	726.39	769.11
179	.6685	4679.2	16.61	106.4	.5408	709.23	760.50	803.46
180	0.7005	4903.8	16.64	111.5	0.5552	743.27	797.29	840.49
181	.7345	5141.8	16.66	116.9	.5705	779.35	836.27	879.71
182	.7714	5399.5	16.69	122.8	.5871	818.40	878.49	922.17
183	.8110	5676.9	16.71	129.0	.6049	860.45	923.95	967.87
184	.8534	5973.9	16.74	135.8	.6240	905.48	972.64	1016.8
185	0.8994	6295.9	16.77	143.1	0.6447	954.27	1025.4	1069.8
186	0.9488	6641.5	16.79	150.9	.6670	1006.7	1082.1	1126.7
187	1.003	7018.2	16.82	159.4	.6912	1063.8	1143.9	1188.8
188	1.062	7431.9	16.84	168.8	.7178	1126.5	1211.7	1256.8
189	1.127	7887.6	16.87	179.1	.7471	1195.5	1286.5	1331.8
190	1.198	8386.0	16.90	190.4	0.7791	1271.1	1368.1	1413.7
191	1.277	8936.2	16.92	202.9	.8145	1354.3	1458.4	1504.2
192	1.364	9545.9	16.95	216.7	.8537	1446.9	1558.4	1604.5
193	1.461	10.229	16.97	232.1	.8976	1550.4	1670.6	1716.9
194	1.571	10,995	17.00	249.5	.9468	1666.5	1796.3	1842.8
195	1.695	11,862	17.03	269.1	1.003	1797.9	1938.5	1985.3
196	1.836	12,849	17.05	291.5	1.066	1947.6	2100.7	2147.7
197	1.998	13,988	17.08	317.3	1.139	2120.2	2287.5	2334.7
198	2.187	15,310	17.10	347.2	1.224	2320.6	2504.6	2552.1
199	2.363	16,538	17.13	375.0	1.303	2506.7	2706.4	2754.1
200	2.673	18,711	17.16	424.1	1.443	2836.1	3063.0	3111.0

Explanation of Table and Its Use

Tables of the psychrometric properties of air for the normal barometric pressure of 29.921 in. have been used for a variety of pressures. However, there are many localities where the tables for normal pressure cannot be used because the average barometric pressure is considerably lower. In addition, there are times in experimental work where errors may result because the variation in barometric pressure is neglected. For these reasons, tables of the psychrometric properties of air have been prepared for barometric pressures from 22 in. to 32 in. of mercury in 1 in. intervals. With the aid of these tables, accurate computations can be made under all conditions.

With a few exceptions, the tables are arranged and used in the same manner as the table for the normal barometric pressure of 29.921 in. of mercury (14.696 lb per sq in.) published in Heating, Piping and Air Conditioning, January, 1938. The columns giving the vapor pressure of moisture and the sensible heat of air are omitted in the new tables because these values are the same as those given in the table for normal barometric pressure. In addition, one column that did not appear in the table for normal pressure appears in the new tables. This is column 7 and is headed *1061w*. The values in this column are of use for quickly computing the *true* enthalpy (total heat) of an air-vapor mixture. For a further discussion of this point, see the January, 1938, HPAC. The quickest way of computing the true enthalpy of an air-vapor mixture is to use formula 3*b* of the January, 1938, article. This formula is

$$h = s''t + 1061w$$

where s'' is the humid specific heat of a saturated mixture at the dew point temperature; w is the absolute humidity in lb; t is the dry bulb temperature; and h is the true enthalpy in Btu per lb of dry air in the mixture

By means of this formula, the true enthalpy of an air-vapor mixture can be computed quickly if its dry bulb and dew point temperatures are known.

Values of s'', the humid specific heat of air corresponding to any given *dew point* temperature, are tabulated in column 6. Values of $1061w$ corresponding to the *dew point* temperatures are tabulated in column 7.

Example: Find the actual enthalpy of a quantity of air if its dry bulb temperature is 90 deg and its dew point temperature is 65 deg. Barometer is 29 in. of mercury.

Solution: Referring to the table, for a dew point temperature of 65 deg, $s'' = 0.2462$, and $1061w = 14.49$.

$$h = s''t + 1061w$$
$$= 0.2462 \times 90 + 14.49$$
$$= 36.65 \text{ Btu per lb of dry air, actual enthalpy}$$

Tables for barometric pressures from 22 to 28 in. inclusive have already been published. The table for 29 in. is given on the preceding page and above.

Heating · Piping · Air Conditioning

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Chapters in 29 cities are carrying on effective work in these communities and every ASHVE member in these cities can and should participate. The local officers need 100 per cent cooperation. The Society's executive officers, President Giesecke, First Vice-president Fleisher and Second Vice-president Eastwood are making official visits to 15 chapters during March and April.

* * *

The Washington Chapter members say, "We want you in Washington June 17-19."

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SOUTHERN CALIFORNIA: *Organized,* 1930. *Headquarters,* Los Angeles, Calif. *Meets,* Second Tuesday in Month. *President,* J. F. PARK, 1234 S. Grand Ave. *Secretary,* E. P. WELLS, 2730 E. Eleventh St.

WASHINGTON, D. C.: *Organized,* 1935. *Headquarters,* Washington, D. C. *Meets,* second Wednesday in Month. *President,* T. H. URDAHL, 726 Jackson Pl., N. W. *Secretary,* P. H. LOUGHRAN, JR., 4513—49th St., N. W.

WESTERN MICHIGAN: *Organized,* 1931. *Headquarters,* Grand Rapids, Mich. *Meets,* Second Monday in Month. *President,* B. F. MCLOUTH, 135 Gunson St., E. Lansing, Mich. *Secretary,* C. H. PESTERFIELD, Mich. State College, E. Lansing, Mich.

WESTERN NEW YORK: *Organized,* 1919. *Headquarters,* Buffalo, N. Y. *Meets,* Second Monday in Month. *President,* L. P. SAUNDERS, 507 Pine St., Lockport, N. Y. *Secretary,* H. C. SCHAFER, 45 Church St., Buffalo, N. Y.

WISCONSIN: *Organized,* 1922. *Headquarters,* Milwaukee, Wis. *Meets,* Third Monday. *President,* H. C. FRENTZEL, 4363 N. Wildwood Ave. *Secretary,* W. A. OUWENEEL, 801 Marshall Ave., South Milwaukee, Wis.

Determination of Cloth Area for Industrial Air Filters

By Charles E. Williams*, Theodore Hatch**, Leonard Greenburg***
(*MEMBER*), New York, N. Y.

FOR the effective removal of microscopic as well as coarser dust particles from the air in industrial exhaust systems air cleaning equipment of the cloth filter type is widely used. From the standpoint of cleaning efficiency and capacity to work against widely varying dust loads and great ranges in particle size the cloth filter has many advantages.

The design of industrial cloth filters with respect to compactness, tight construction, effectiveness of cloth cleaning, ease of inspection and maintenance and other details, has been highly developed by the manufacturers and for most problems it is only necessary to select a stock unit of the proper size to give satisfactory operation. To the user of such equipment, therefore, the question of greatest importance is the size or cloth area required for successful results.

The area of cloth required in an industrial air filter is determined in the main by two values; the rate of air flow (cubic feet per minute) through the exhaust system in which it is to be used and the rate of filtration required for satisfactory filter operation. The filtering velocity varies in general practice between 1.5 fpm and 5.0 fpm with a most common value of 3.0 fpm, velocities within this range having been determined by experience to give the desired results. One notes, however, that this experience has not been reduced to its fundamental terms and expressed quantitatively.

The requirements of good filter performance are:

1. The efficiency of air cleaning must be high enough to meet the specifications of the particular installation with respect to the permissible dust concentration in the discharged air.
2. The resistance to air flow through the filter shall not exceed the maximum value which was used in making the original calculation for determining the size and capacity of the fan. When the filter resistance exceeds this value, the rate of air flow decreases, perhaps below the safe limit for effective dust control.
3. The maximum filter resistance shall not be developed before the end of the specified time of operation between cleaning periods, as for example, one working shift.
4. The maximum resistance allowed for in the design shall be consistent with reasonable power consumption and shall also be kept below the danger point from the standpoint of loss of filtering efficiency and good filter maintenance.

With respect to the first of these criteria, one may say that the cloth specifications and the design of commercial filters have been developed to meet the modern standards of industrial hygiene which require a high efficiency of air cleaning. Limited studies indicate that the cleaning efficiency does not vary significantly with the filtering velocity *per se;* satisfactory results having been obtained under certain conditions with velocities up to 40 fpm. The filter operation is, however, influenced by the pressure drop across the cloth. When the resistance becomes too great, the dust deposit which forms the actual filter breaks and allows dust particles to pass through. The safe maximum filter resistance is not a fixed value but varies with the kind and size of particles in the dust deposit. With rock dust the authors obtained high filtering efficiency with resistances up to 12 in. water gage, a figure that is rarely met with in industrial filter installations, since it represents an excessive waste of power and requires heavy construction of the filter house.

Experience in the field has led to the general acceptance of 3 in. water gage as the maximum filter resistance for good operation. This figure, which is easily maintained at filtering velocities for the most part within the range of 1.5 to 5.0 fpm, represents a compromise between the initial cost of the filter, on the one hand, and annual cost of power consumed by the filter and the cost of filter maintenance, on the other. It is well below the danger point of cloth failure and loss of efficiency for most dusts.

Referring to the four basic requirements for good filter operation cited above, one sees that these may be reduced to the one criterion of filter resistance and the problem of filter design becomes one of determining the cloth area such that the resistance does not increase beyond 3 in. water gage or some other acceptable maximum value within the operating time between cleaning periods which is fixed by the plant schedule.

Thus, the maximum resistance and the cleaning interval should be specified by the purchaser from which the filter area should be determined. At the present time this cannot be done because of the lack of essential data concerning the resistance characteristics of different industrial dusts and loadings that are encountered in industrial exhaust systems.

Present empirical methods of selecting cloth area may result not only in undersize filters but also in units that are needlessly large and costly. For example, two cloth filter installations when recently tested were found to develop resistances of 5.0 in. and 0.5 in. water gage after 4 hours and 6 days of operation respectively. The velocity of filtration was approximately 2.0 fpm in the first case and 3.0 fpm in the second and the loading was about the same in both systems. There was great difference, however, in particle size of the collected dust, the higher resistance being associated with the finer material. Failure to take this into consideration resulted in an undersize filter in the one case and one which was unnecessarily large in the second.

In the discussion which follows the fundamental rela-

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tionship which is involved has been developed, and also reported in preliminary form are the resistance coefficients for certain industrial dusts. The extension of this method of approach to the study of actual field installations will provide some of the design data now lacking and thus insure more satisfactory results.

Filter Resistance

For a given filter with a fixed dust load, the resistance to air flow varies directly with air velocity, since the flow is streamline in character. For a complete expression of the relationship between filter resistance and filter operation, however, one must consider several additional factors including the size and shape of the dust particles caught on the filter, the packing characteristics of the dust (denseness of the dust layer) and the amount of dust on the filter at the end of any given period of operation.

In addition, the viscosity and density of the air affect the resistance. Fundamentally, the relationship is the same as that involved in chemical filtration, or the flow of fluids through beds of granular materials. Many filtration equations have been developed which vary in their details although all originate from Darcy's well-known formulation. Among the most recent of these is that presented[1] in 1933 which has the following form:

$$H_t - H_1 = H = \frac{k}{g} \cdot \frac{\mu}{\rho} \cdot v \cdot l \cdot \left(\frac{A}{V}\right)^2 \cdot \frac{(1-\alpha)^2}{\alpha^3}$$

where H_t = loaded filter resistance, feet of fluid (air)
H_1 = initial cloth resistance, feet of fluid
H = increase in resistance due to dust load, feet of fluid
l = depth of dust deposit on filter, feet
k = coefficient
g = acceleration due to gravity
μ = air viscosity, English units
ρ = air density, pounds per cubic foot
v = average filtering velocity = rate of air flow ÷ effective filter area, feet per second
V/A = ratio of volume to surface area of the dust particles on the filter, feet
α = porosity of the filter bed = volume of voids ÷ total or bulk volume of dust.

The depth of the filter bed, in the above equation, may be expressed in terms of the weight of dust per unit of cloth area and the density and porosity of the dust as follows:

$$l = \frac{w}{\rho^1 \alpha}$$

where w = weight of dust on the filter per unit of cloth area, pounds per square foot
ρ^1 = real density of the dust, pounds per cubic foot

This expression may be further modified to include the time factor by substituting for w the following:

$$w = \frac{L.t.v.}{7000}$$

where L = loading of dust coming to the filter per unit of air volume, grains per cubic foot
t = elapsed time of operation in seconds during which the filter resistance increased H feet

With these modifications, the complete relationship becomes:

$$H = \frac{k}{g} \cdot \frac{\mu}{\rho} \cdot \left(\frac{A}{V}\right)^2 \cdot \frac{(1-\alpha)^2}{\alpha^4} \cdot \frac{v^2 L t}{7000 \rho^1}$$

This equation shows that the resistance varies directly with kinematic viscosity of the air, with the dust load per unit air volume and with time of operation and inversely with the density of the dust. It also varies with the square of the filtering velocity and inversely with the square of the particle size as measured by V/A.

Of particular interest is the effect of porosity which appears in the equation as a complicated exponential function of great sensitivity. According to this function, a slight change in porosity as for example, from 0.4 to 0.42, causes a considerable decrease in the filter resistance, amounting to 23 per cent in the example cited. One cannot measure α directly since the depth of bed, l, is indeterminate. Hence, the porosity factor has no quantitative value in the equation. The example, however, demonstrates its great importance in determining the filter resistance. The porosity of the dust deposit varies significantly in practice. For crushed rock of fairly uniform size and shape the porosity falls within the range of 0.38 to 0.44. If the uniformity of size is low, the porosity is reduced since the fine particles lodge in the interstices between the large particles. Particle shape is also important; irregular fluffy particles do not pack as closely as grains of flat or round shapes. Materials which are moist or greasy tend to pack more than dry materials which in certain cases have been found to carry electrostatic charges which tend to keep the particles apart. The condensation of water vapor on a filter bed closes the voids in the deposit and increases the resistance greatly. This occurs when moisture-laden air is cooled in passing through the filter. Thus, atmospheric conditions and the moisture content of the dust play an important part in filter operation.

The importance of particle size in determining resistance is indicated by the fact that the V/A ratio is squared in the equation. This explains in part why materials of extremely fine size, such as lampblack and lead oxide, are difficult to filter and why wood dust and grain dust on the other hand are relatively easy to collect by filtration.

A primary separator installed ahead of the filter removes part of the dust load before reaching the latter and thus reduces the filter resistance for a given initial dust load. It is interesting to note, however, that the benefit derived therefrom is not directly proportional to the reduction in the filter dust load, owing to the fact that the particle size of the material passing through the primary separator is considerably smaller and as a consequence has a much greater inherent resistance than the original material.

For example, in one installation with 93 per cent removal in the primary separator it was found that the reduction in the filter resistance was only 30 per cent

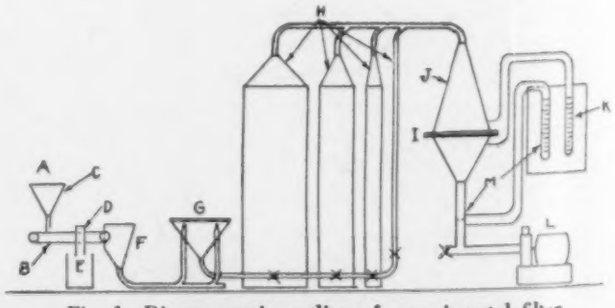

Fig. 1—Diagrammatic outline of experimental filter

[1] Fundamental Factors Governing the Stream Line Flow of Water Through Sand, by G. M. Fair and L. P. Hatch. *Trans. Am. Wat. Wks. Assn.*, 1933, *25*, 1551.)

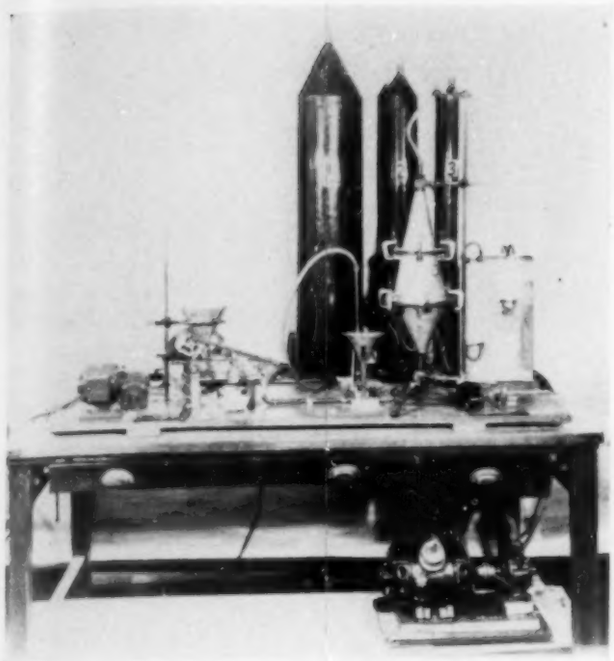

Fig. 2—Experimental filter

as compared with its resistance without primary separation, that is to say, with a loading 14 times as great. Thus, the inherent resistance of the filter dust after primary separation was ten times greater than that of the original mixture. Under certain conditions the use of primary separation may even be carried too far, as, for example, when the resulting fine material adheres to the cloth in greater amounts than would be the case when coarser particles are also present, thus losing the beneficial effect of self-cleaning which limits the filter loading.

Experimental

It is clear from the foregoing that the selection of the required filtering velocity depends upon several factors in addition to the kind of material to be collected. It appears from the equation that one material is different from another only in the degree to which the size and porosity values differ. The loading and specified time of operation are also of importance and must be considered in any problem.

Owing to the difficulty of determining $\propto$ and V/A for a given material, it is best to combine these with the coefficient k into one resistance coefficient, r, thus simplifying the equation to the following:

$$h_t - h_i = h = rVw = \frac{rLTV^2}{7000}$$

where h_t, h_i and h are expressed in inches water gage

r = specific resistance of the dust, inches water gage per pound dust per square foot cloth area per feet per minute filtering velocity

L = dust load in air coming to filter, grains per cubic foot

T = time in minutes for filter resistance to increase h inches water gage

V = filtering velocity, feet per minute

This paper reports in preliminary form some values of the resistance coefficient for certain industrial dusts and for different sizes of the same dust. These values are for room-dried material.

The apparatus employed for these tests is shown in Figs. 1 and 2. It consists of five essential parts: a constant-feed device; a means for breaking up aggregates and dispersing the dust; elutriating towers for control of particle size; the test filter and the exhaust pump; and air-flow meter. The constant-feed apparatus, *A*, employs a slow speed belt conveyor, *B*, which draws a ribbon of dust from the storage hopper, *C*. The cross-sectional area of the ribbon is reduced to a constant value by passing through a fixed opening, *D*, the excess dust falling into discharge chutes, *E*. The capacity of the apparatus can be varied over a considerable range with a lower limit of approximately 0.5 g (gram) per minute for rock dust. The dust falls off the belt into a funnel, *F*, which serves as the air inlet to the test filter. The dust is picked up in the air stream and conveyed pneumatically to the disintegrating impinger, *G*, which operates at approximately 20,000 fpm with the impinging plate about ¼ in. from the end of the nozzle. This serves effectively to break up the flocculated dust and insures a uniform dispersion in the air. The dust-laden air next passes through one of the four elutriating towers, *H*, in which the vertical velocities are respectively 4000 fpm (no size separation), 60 fpm, 20 fpm and 4 fpm when the volume rate is 2.0 cfm. At the three low velocities the theoretical maximum sizes of particle lifted (silica) are: 90μ, 45μ and 20μ. The dust thus limited with respect to particle size is next conveyed to the test filter, *I*, which has a long tapered inlet, *J*, to insure a uniform deposition of dust over the entire area of the filter. The test cloth, which is easily removed, is supported by means of a second piece of cloth, stretched tightly to prevent sagging which was found to affect the resistance. The cloth is mounted horizontally so that no dust falls off during a test. Pressure taps on either side of the filter are connected to a water manometer, *K*, to indicate the filter resistance.

Air flow through the apparatus is produced by means of a positive displacement pump, *L*, with a capacity of 3 cfm against a resistance of 3 in. mercury. This high resistance pump is necessary because of the pressure loss through the disintegrating nozzle. An orifice and manometer, *M*, measure the rate of air flow through the filter. The filter area is 0.2 sq ft and the rate of air flow commonly set at 2.0 cfm, giving a filtering velocity of 10 fpm.

The procedure for running a test was as follows: A clean and weighed filter disk is placed in the apparatus; the storage hopper filled with the test dust and connections made to the proper elutriating tower. The pump is started, the flow adjusted to 2.0 cfm and the initial resistance recorded. After this the constant feed device is started and the time recorded. The change in resistance with time is noted at two minute intervals and the test continued until the filter resistance has increased to approximately 8 in., the rate of air flow being kept constant at 2.0 cfm during the run. At the conclusion of the test the filter cones are carefully separated and the cloth removed and weighed.

The coefficient r is calculated directly from the test data in the manner illustrated by the following example:

Test dust: Granite >20 mesh
Elutriation tube used: none
Test period: 20 min
Rate of air flow = 2 cfm

Filtering velocity = 10 fpm = V
Initial filter resistance = h_i = 0.4 in.
Final filter resistance = h_f = 7.0 in.
Weight cloth, loaded = 48.44 g
Weight cloth, clean = 11.04 g
Weight dust deposit = 37.4 g = 0.412 lb per square foot = w
From these data, r is determined as follows:

$$r = \frac{h}{wV} = \frac{7.0 - 0.4}{0.412 \times 10} = 1.6 \text{ in. water gage.}$$

Results

In the early part of the study special observations were made to test the validity of the fundamental equation with respect to the linear function of velocity and loading. For this purpose a series of tests was made with a given dust but different loadings and for filters with fixed dust loads the resistance-velocity relationship was observed over a range of velocities.

The data plotted in Fig. 3 show how the filter resistance increases with time of operation. The increase is approximately uniform and since the rate of feed of dust was constant this indicates that the filter resistance varies directly with the weight of dust deposited on the

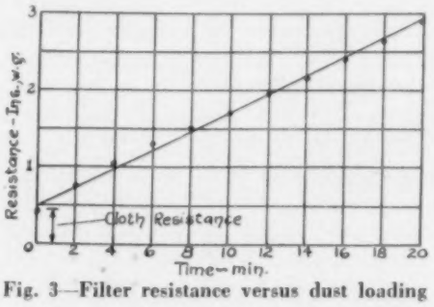

Fig. 3—Filter resistance versus dust loading

filter. Lines with different slopes were obtained with different dust loadings in the air but when the resistance values were divided by the corresponding dust loadings, a single line was obtained upon which all the points fell, thus demonstrating further that the filter resistance varies directly with the weight of dust deposited on the filter.

The relation between filtering velocity (clean air) and filter resistance is shown in Fig. 4 for three different filter loadings. Again, a linear relationship (45 deg line on log paper) in keeping with the fundamental equation may be noted.

Relationships similar to those shown in Fig. 3 were obtained for the whole series of dusts and from these the value of r was calculated for each test dust. The resulting values of the resistance coefficient r are presented in Table 1 for different sizes of the several dusts, the size being indicated in a qualitative rather than a quantitative manner in this preliminary report.

The data suggest a number of important points:

1. The resistance coefficient increases many-fold when the particle size varies from *coarse* to *fine*.

2. The resistance coefficient does not vary greatly among the several materials studied when these are compared at equivalent sizes.[2]

3. These data explain why certain materials like lampblack are hard to filter. This difficulty is not inherent in the material but is due to the extremely fine size of the individual particles.

[2]Note, however, that r is not corrected for variations in ρ^1.

Table 1—Filter Resistance Coefficients for Certain Industrial Dusts[a]
(*Industrial cloth-type air filters*)

Material	Particle Size						
	Coarse			Medium[c]		Fine[c]	
	<20 Mesh	<140 Mesh	<375 Mesh	<90 μ	<45 μ	<20 μ	<2 μ
Granite	1.58	2.20	.....	.....	.....	19.8	.....
Foundry	0.62	1.58	3.78	.....	.....	.....	.....
Gypsum	.....	.....	6.30	.....	.....	18.9	.....
Feldspar	.....	.....	6.30	.....	.....	27.3	.....
Stone	0.96	.....	.....	6.30	.....	.....	.....
Lamp Black	.....	.....	.....	.....	.....	.....	47.2
Zinc Oxide	.....	.....	.....	.....	.....	.....	15.1[b]
Wood	.....	.....	.....	6.30	.....	.....	.....
Resin (cold)	.....	0.62	.....	.....	.....	25.2	.....
Oats	1.58	.....	.....	9.60	11.0	.....	.....
Corn	0.62	.....	1.58	3.78	8.80	.....	.....

[a]Inches, water gage, per pound dust per square foot cloth per foot per minute filtering velocity.
[b]Flocculated material not dispersed, size actually larger.
[c]Theoretical size of silica; no correction made for materials having other values of ρ^1.

There was some evidence of a low filtering efficiency against lampblack, which suggests that the safe filter resistance for this material was exceeded during the tests. In practice, it may be necessary to establish a maximum filter resistance for very fine materials ($< 1\ \mu$) below 3 in. water gage.

It must be made clear that the resistance data here reported were obtained in the laboratory and are not applicable to field problems except in a relative way. One can only say from these values that a given material has a resistance coefficient equivalent to or different from that of a standard dust like granite, for example, and estimate the behavior of this dust during filtration upon its relative value of r. It remains to make comparable field studies and thus secure values of r, for representative industrial installation. The collection of such data requires only that filter resistance be determined at the beginning and end of a full operating period and that the amount of dust collected during this run be measured. If a primary separator is employed, the amount of dust collected in it and its resistance should also be determined since it is necessary to know the benefit obtained from the preliminary removal of the large particles.

Summary

In the present paper an attempt is made to reduce the problem of determining the cloth area of industrial cloth filters to its fundamental terms. Filtering velocity is shown to have little importance *per se* as a criterion of filter operation and in its place emphasis is placed upon the maximum allowable filter resistance, a practical limit for which is fixed at 3 in. water gage. This repre-

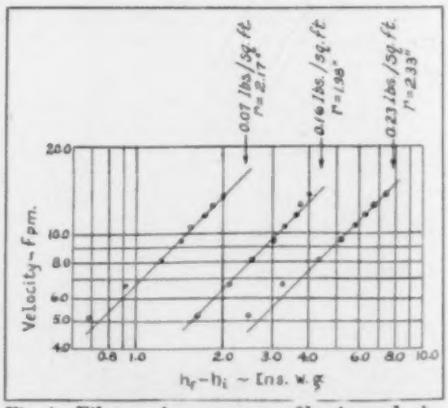

Fig. 4—Filter resistance versus filtering velocity

sents a compromise between initial filter cost and power and maintenance cost. It is well below the danger point with respect to safe filter operation for all dusts except those of extremely fine particle size, such as lampblack. For practical operation, the maximum allowable resistance must not be reached until the end of the required period of operation between cleaning periods. Thus, the basic filter specifications are (1) maximum allowable resistance and (2) minimum operating time. It is suggested that these should be specified by the purchaser of cloth filters and that the required filtering velocity be determined from the values thus fixed.

The filter resistance is shown to be dependent upon several factors of which velocity of filtration is only one. Others of equal or greater importance are the particle size of the dust, the porosity of the deposit on the filter, and the loading of dust. A resistance equation is presented in which these several factors are combined in their proper form.

The resistance coefficients for several industrial dusts, based upon laboratory studies, are also given. They are shown not to vary significantly among the several materials studied but to depend primarily upon the particle size of the dust. Within the range of sizes occurring in industrial exhaust systems the coefficient was found to vary many-fold.

Atlanta Chapter Meets

March 4, 1940. The regular monthly meeting of the Atlanta Chapter was held at the Biltmore Hotel, where supper was served preceding the meeting which was called to order by Pres. T. T. Tucker. Following the reading of the minutes of the previous meeting, which were approved as read, the minutes of the Chapter Delegates Conference at Cleveland were filed with the secretary.

The research committee reported that a research program at Georgia Tech has been approved by Dr. Brittain, and a project is now under discussion. S. W. Boyd reported on the smoke abatement campaign. A motion was introduced and passed requesting Mr. Boyd to consult Professor King with reference to the establishment of a speakers bureau in the Atlanta Chapter, to furnish speakers for smoke abatement meetings of local organizations. Members Koch, Gorbandt, Cole, Nolan, Kent, Boyd, Tucker, McCain and Dunn volunteered to serve on this committee if established.

Following a discussion on the possibility of a joint meeting with affiliated societies to hear a report from Professor King with reference to the smoke abatement investigation, F. L. Laseter spoke on the application of natural gas to summer air conditioning.

T. J. Durrett, technical director of Atlanta Housing Authority, gave an interesting talk on some of the details and cost data in connection with the slum clearance program in Atlanta, which was followed by adjournment.

Architects' and Engineers' Classified Directory

Publication of the first edition of a classified directory containing 2000 listings, over 200 of architects, engineers and builders, and nearly 400 building material manufacturers, distributors and contractors, all having offices or permanent exhibits in the Architects Building, New York, N. Y., has been announced by Stephen F. Voorhees, president, Architects Offices, Inc., owners of the building. The directory is distributed gratis to architects, builders, and other buyers in the building industry. This building, which houses the largest group of professional and business firms in the building industry assembled under one roof, also is the headquarters of 9 trade associations.

Michigan City Member Awarded Life Membership

W. R. Stockwell

William R. Stockwell of Weil-McLain Co., Michigan City, Ind., has been voted Life Membership in the Society by the Council.

Mr. Stockwell, born in Erie, Pa., joined the Society in 1901 as a Junior Member, and in 1903 was elected to Member grade. After attending the local high school, he completed the heating and ventilating course of International Correspondence School, and then attended New York Trade School, where he received his shop experience in steam fitting. His drafting experience was with J. D. Clarke, where he estimated and superintended work in connection with the heating and ventilation of buildings.

In 1901 he entered the employ of Lord & Burnham Co., Irvington-on-Hudson, N. Y., as salesman for low pressure, steam and hot water boilers. Shortly afterward he was placed in charge of the boiler and heating department. Spending more than 15 years with that company he later became associated with The J. H. McLain Co., Canton, Ohio. In 1921 this company was absorbed by the Weil-McLain Co., and their plant moved to Michigan City, Ind., where Mr. Stockwell has remained ever since, as general manager of the manufacturing division.

Mr. Stockwell is now one of a rather limited group who are entitled to a place on the rolls of the Society as a Life Member.

Progress of Committee on Thermal Insulating

Committee C-16 on Thermal Insulating Materials and its subcommittees held a two-day meeting in Detroit March 7-8 in connection with the *American Society for Testing Materials'* Committee Week. This committee, under the chairmanship of J. H. Walker, Detroit, Technical Adviser of the Society's Committee on Research, has been actively working since its organization in 1938, on a program for the formulation of test methods and specifications relating to industrial thermal insulating materials (except those used in the building and insulating refractory fields.)

At its meeting the committee gave consideration to methods for determining the physical properties of preformed insulation and also to tests for thermal properties, except thermal conductivity, of all forms of insulation. The sub-committee responsible for flexible, blanket, loose-fill, and miscellaneous insulation also held a well attended meeting at which its program of work on this subject was furthered.

Considerable progress has been made in the preparation of standard physical test methods for various types of insulating materials. The tests under development cover procedures for determining compressive strength, flexural strength, impact resistance, etc. It is expected that within the coming year these methods will be ready for final approval by the committee.

The committee on thermal conductivity which functions as a joint committee of the American Society of Heating and Ventilating Engineers, *American Society of Refrigerating Engineers*, National Research Council, and *ASTM*, also held a meeting at which its program of work was considered. This joint committee is studying three different types of conductivity test, the guarded hot-plate method, the guarded hot-box method, and the guarded-end cylinder method for testing cylindrical pipe coverings. The test procedure by the guarded hot-plate method is practically completed.

Pittsburgh Experiment Station of the U. S. Bureau of Mines where the Research Laboratory of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS is located

Heat Gain Through Glass Blocks by Solar Radiation and Transmittance

By F. C. Houghten*, David Shore**, (*MEMBERS*), H. T. Olson*** and Burt Gunst†
Pittsburgh, Pa.

THE growing use of glass block in buildings provided with summer cooling and air conditioning has made it increasingly desirable that acceptable design data on heat gain through such constructions be established. There has been emanating from the field such diverse information, that, even though some of it came from accredited research sources, it was deemed expedient that the ASHVE Research Laboratory, in the light of its disinterested position in the industry, make independent research to establish data on which both the public and the manufacturers could rely, completely and authoritatively. Having in our own Society representatives not only from the technical schools of the country, but also from the manufacturing, engineering and contracting groups, organized into a Technical Advisory Committee to investigate any subjects pertaining to the use of glass in air conditioning buildings, the taking up of this matter at this time is proper and logical. Consequently, exhaustive research was started at the Society Laboratory with the latest and most complete equipment, from which the results indicated in this paper emanated. A more detailed report covering additional phases of the subject will appear in the Transactions of the ASHVE.

The study was made at the Research Laboratory in Pittsburgh in a two-room test house, Figs. 1 and 2, built for the purpose on the roof of the Bureau of Mines warehouse building. The design of the rooms and the test procedure were similar in many respects to those used in an earlier Laboratory study[1] of sun radiation gain through windows. Each room was about 7 ft x 7 ft x 8 ft high inside, and was designed so as to provide for the insertion of a 4-ft x 6-ft window panel in one side. The test house was built on a turntable so that these windows could be faced in any direction. The walls of each room were well insulated, having an air to air transmittance coefficient of 0.06 Btu per square foot per hour per degree Fahrenheit. They were painted aluminum on the outside to minimize the absorption of solar radiation, and in addition, the two sides and the top surface were shaded from sun radiation by canvas placed on a framework about 1 ft from these surfaces. The inside walls, ceilings, and floors were painted white. Black cheesecloth screens placed within the rooms intercepted direct radiation from the sun so as to make this heat gain immediately effective in raising the air temperature of the rooms and therefore in the measured cooling load.

Although in the construction of the test house all the joints were made tight and then sealed in order to reduce infiltration to a negligible value, tests were made by the carbon dioxide dilution method under different weather conditions to determine the rate of infiltration for each room. It was found that this rate did not exceed 0.03 air

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Presented at the 46th Annual Meeting of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS, Cleveland, Ohio, January, 1940.

[1]Studies of Solar Radiation Through Bare and Shaded Windows, by F. C. Houghten, Carl Gutberlet and J. L. Blackshaw. (ASHVE TRANSACTIONS, Vol. 40, 1934, p. 101).

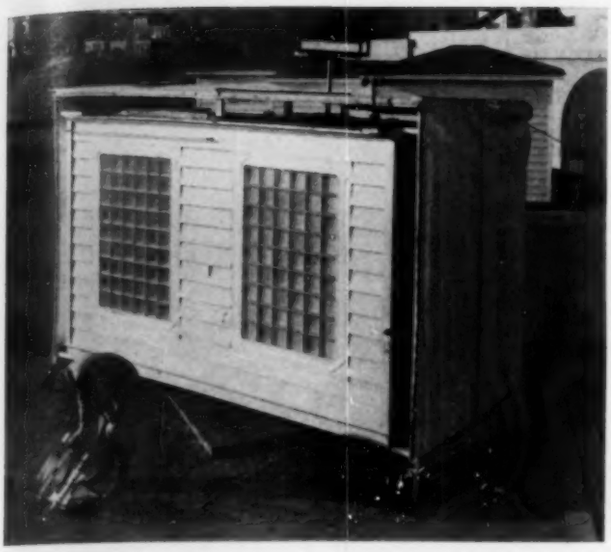


Fig. 1—Test house with glass block panels in position for test

change per hour. With the maximum outside to inside air temperature difference observed for any test, this gave a total heat gain for one room of 4.5 Btu per hour, or 0.19 Btu per square foot of glass.

Each room was provided with a cooling unit, modified so that a constant volume of air was taken from within 4 in. of the floor, passed over the ice, or around it through a by-pass, over the electric heaters, through an auxiliary fan and then dispersed into the upper part of the room through a conically shaped cheesecloth bag with air velocities not exceeding 38 fpm at any point within 6 in. of any wall surface. The rate of cooling was controlled by by-pass dampers operated from the outside of the room. The drip from the melting ice was piped to weighing buckets in the observation room and weighed at 20-min intervals. A thermostat within each room controlled a small electric heater, located so as not to affect the ice meltage, in the air stream through the cooling unit. This arrangement gave a lateral distribution of cooled air near the ceiling which was then drawn downward to the floor. The rate of air change was adjusted to 24,400 cu ft per hour which was estimated to give the most satisfactory relationship between air velocity and air temperature difference between inlet and outlet. With maximum heat gain on hot sunny days this gave a temperature difference of 5.2 deg.

In conducting a test, the by-pass damper in each cooler was adjusted to give a cooling rate a little greater than the estimated heat gain. The heating capacity of the electric heater was then adjusted to a value a little greater than necessary to maintain the uniform temperature desired. The thermostat then maintained this temperature by intermittent operation of an electric heater. The total cooling load for each room was then taken as the difference between the cooling measured by the ice meltage and the electric input, both of which were observed at 20-min intervals. As the cooling load changed throughout the day, the by-pass damper adjustment was changed between the 20-min observation intervals.

The heat gain through the floor, ceiling, and walls other than the glass, was determined by Nicholls' heat flow meters attached to these areas, and the total heat gain through the glass was determined as the difference between the total cooling load and the heat gain through the other parts of the structure. The emf's given by the Nicholls' heat flow meters, and the thermocouples giving the temperature of the air at the center of each cubical, the temperature gradient throughout the room, the inside and outside surface temperatures, and the air temperature 6 in. from either side of the glass, were observed by a precision potentiometer located in the adjoining observation room. The solar radiation normal to the direction of the sun's rays was observed by potentiometer readings of the emf set up by the Laboratory pyrheliometer described in an earlier Laboratory publication.[2] The sun radiation intensity impinging normal to outside vertical glass surface was observed by a low sensitivity type

[2]Heat Transmission as Influenced by Heat Capacity and Solar Radiation, by F. C. Houghten, J. L. Blackshaw, E. M. Pugh and Paul McDermott. (ASHVE Transactions, Vol. 38, 1932, p. 231).

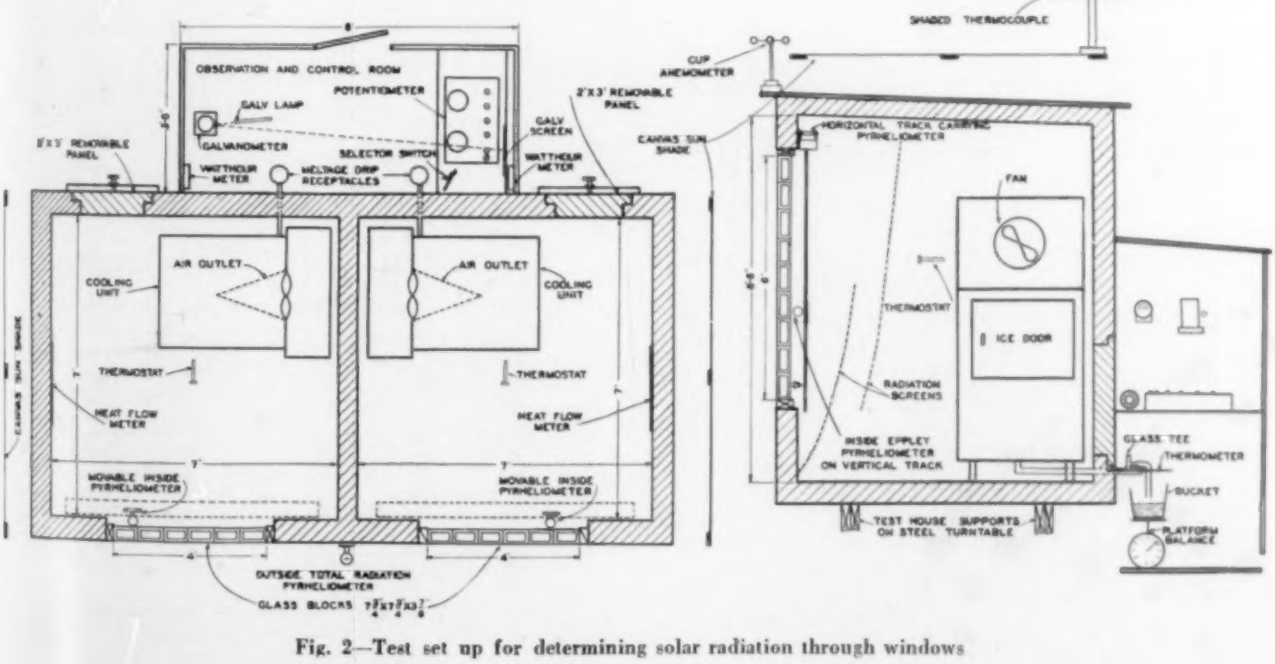


Fig. 2—Test set up for determining solar radiation through windows

Table 1—Description of Glass Blocks Studied and Design Heat Gain Data for a South Exposure

Block	Outside Surface	Inside Surface	Block Air Space Surfaces		Design Heat Gain for August 1 at 41 deg N Lat in Btu per sq ft			
			Outer	Inner	Radiation		Total	
					Max. Per Hour	Per Day[a]	Max. Per Hour	Per Day[a]
A	Smooth	Smooth	Vertical Ribs	Horizontal Ribs	22.0	115.5	40.5	250.4
B	Vertical Ribs	Vertical Ribs	Smooth	Smooth	19.8	100.3	38.4	233.6
C	Ribs on one or both surfaces		Horizontal Prismatic Ribs	Horizontal Prismatic Ribs	17.0	91.8	35.0	216.8

[a] 9:00 a. m. to 5:00 p. m.

Eppley pyrheliometer attached to the wall of the building between the two windows. A second high sensitivity type Eppley pyrheliometer located inside of each room, with its sensitive plane parallel to the inside surface of the glass panel, and moved about so as to traverse a 3-ft x 3-ft area was used to measure the amount of radiation passing through the glass panel. This was accomplished by mounting the pyrheliometer on a vertical carriage to give it the vertical translation, this carriage in turn, being suspended from a horizontal carriage to give it the horizontal translation. The speed of these two movements was then regulated so as to give an approximately constant pyrheliometer reading. The Eppley instruments have plane sensitive elements so located as to have a view of the entire hemispherical angle or a solid angle of π radians, unobstructed by any throat or aperture through which the sun must shine as is the case with the ASHVE Laboratory and the Abbot Silver Disk instruments. The Eppley instruments have their sensitive elements encased in a thin glass dome which absorbs a certain percentage of the solar radiation impinging on the outside. This absorption is selective and includes a larger percentage of the long waves, the glass being opaque[3] to practically the entire radiation from a black body source below 400 F. The calibration of the instrument includes a correction for that part of the solar radiation which it absorbs; however, when the instrument is used to measure radiation from temperature sources lower than the sun a considerable error results. As an example, the use of these instruments inside the rooms measured satisfactorily that portion of radiation which came through the glass, but as should be expected they were not at all sensitive to re-radiation from the inside surface of the glass block, which must have been considerable because of its elevated temperature.

This was easily demonstrated by quickly shading the outside of the glass panel at the middle of the day when the glass temperature was at its highest due to previous absorption of solar radiation. This shading, of course, suddenly eliminated the transmission of solar radiation through the glass but did not immediately affect the re-radiation from the inside surface. Nevertheless, the reading of the pyrheliometer in the room was reduced to zero.

The Eppley pyrheliometer observations were made with the precision type potentiometer in the observation room. The wind velocity was observed by a cup-type anemometer and the outside shade temperatures were determined with a thermocouple located about 3 ft above the top of the building.

[3] Radiation of Energy Through Glass, by J. L. Blackshaw and F. C. Houghten. (ASHVE Transactions, Vol. 40, 1934, p. 93).

Six different designs of glass blocks were tested, three made by each of two manufacturers. All of the blocks were 7¾ in. x 7¾ in. x 3⅞ in. which, with a ¼-in. mortar joint, filled an 8-in. x 8-in. wall area. Blocks of each design were made up into a 4-ft x 6-ft glass block panel in a wooden frame. This frame containing the glass panel could then be placed into the opening in either room, fastened in place, and then caulked with hair felt for insulation. The joint was taped on either side so as to eliminate air leakage. With this arrangement glass block panels could be made up and allowed to age before being put into place for test.

The six designs of glass blocks tested were chosen in pairs having certain common characteristics, including one design from each manufacturer. The characteristics of the designs and key letters used for the different blocks tested are given in Table 1. By agreement individual ratings of the several blocks of the two manufacturers are not given, but rather the average performance for each of the three types.

As an example of the way the data were treated, a record of the results for one glass panel during a test on August 23 when the glass was facing south is shown in Fig. 3. This was a fairly cool but bright sunny day when the outside air temperature above the building, Curve *A*, reached a maximum of 90 F and the Pittsburgh station of the Weather Bureau recorded a maximum of 87 F.

The results of three fairly satisfactory tests on the *A* panels facing south are given in Fig. 4, showing from top to bottom, outside air temperatures, solar radiation intensities normal to the outside surface of the panels, radiation through the panels, the difference between the

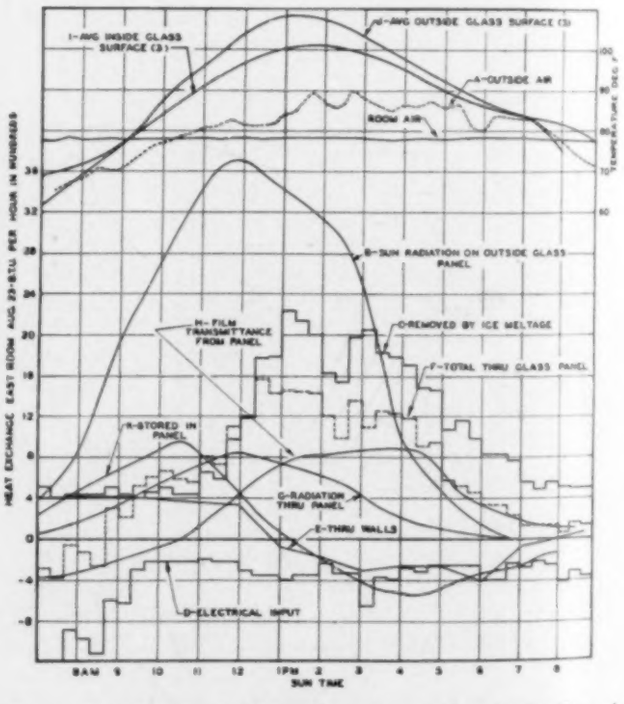


Fig. 3—Test data for Aug. 23. East room equipped with Type *A* glass block panel. All heat exchange rates apply to the entire room or the 24 sq ft panel

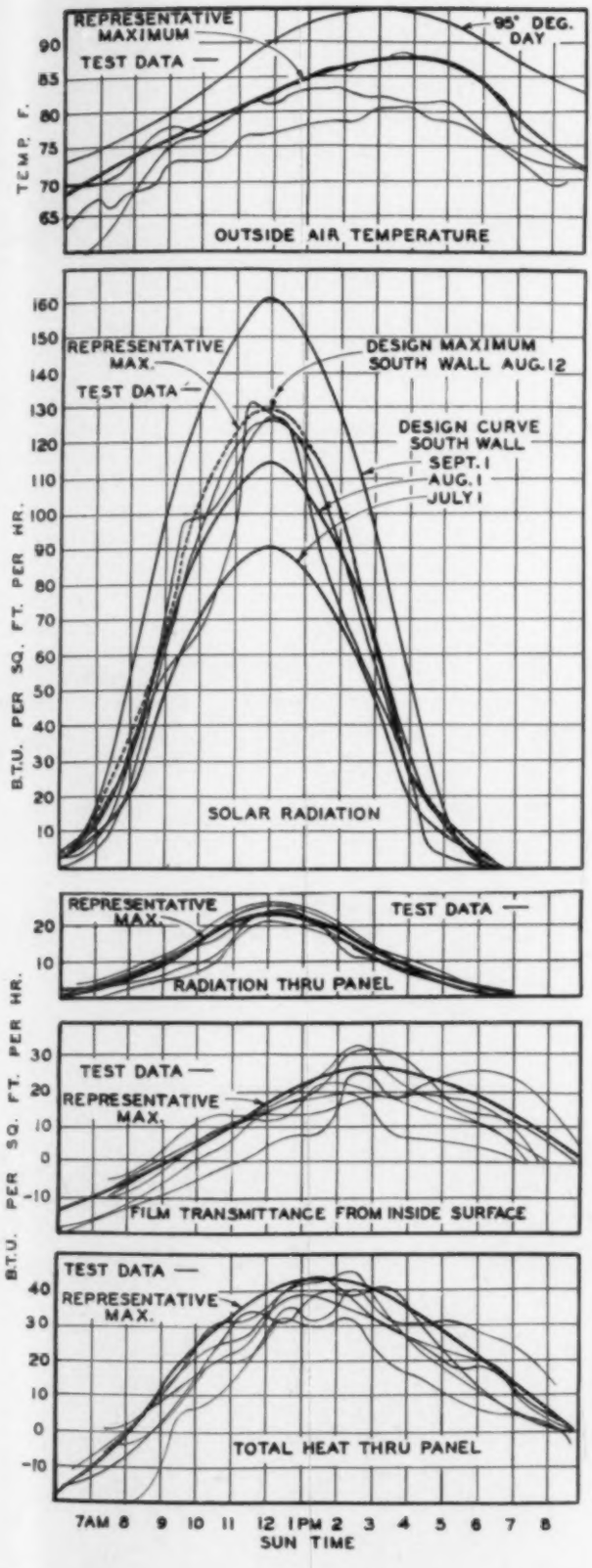


Fig. 4—Test data for two Type *A* glass blocks for Aug. 10, 11 and 14 with representative maximum curves. Design sun radiation curves for south wall and outside air temperature curve for 95 F day also given

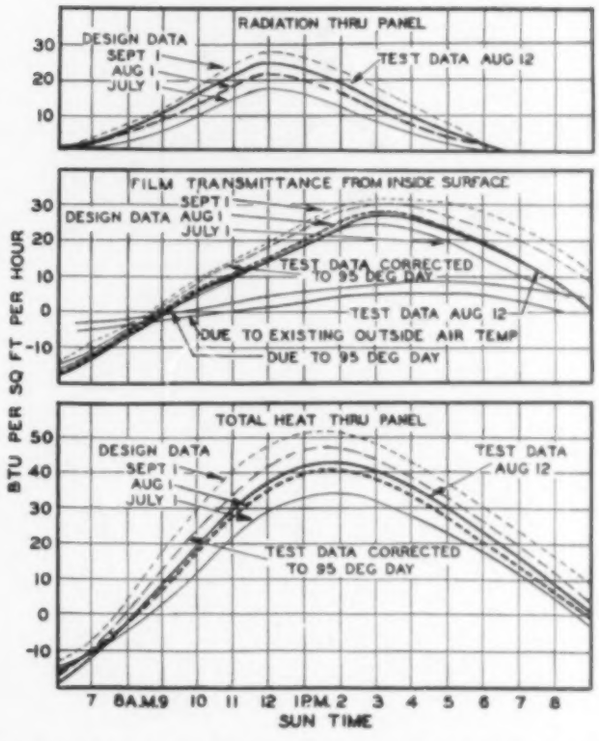


Fig. 5—July 1, Aug. 1 and Sept. 1 design data for total heat gain and gain by radiation and transmittance from inside surface for Type *A* glass blocks based on design radiation curves and 95 F outside temperature curve of Fig. 4, for south wall

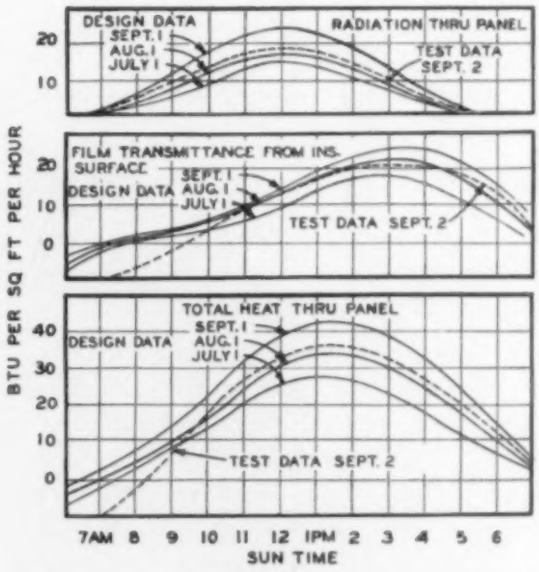


Fig. 6—July 1, Aug. 1 and Sept. 1 design data for total heat gain and gain by radiation and transmittance from inside surface for Type *B* glass blocks based on design radiation curves and 95 F outside temperature curve of Fig. 4, for south wall

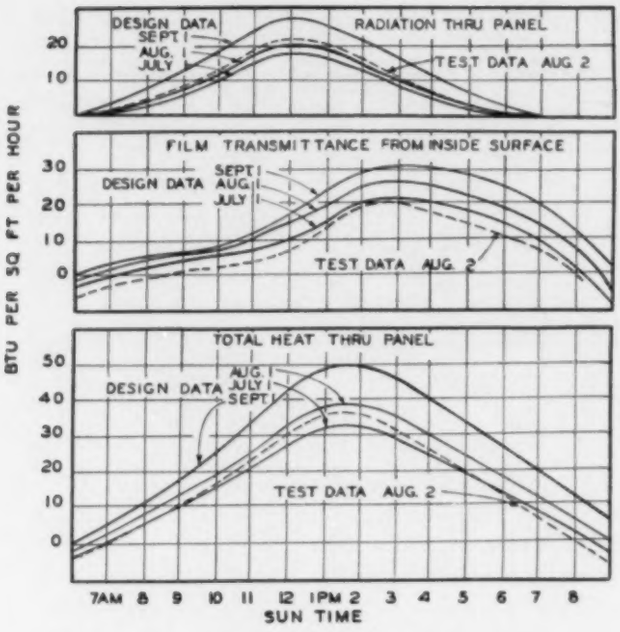


Fig. 7—July 1, Aug. 1 and Sept. 1, design data for total heat gain and gain by radiation and transmittance from inside surface for Type *C* glass blocks based on design radiation curves and 95 F outside temperature curve of Fig. 4 for south wall

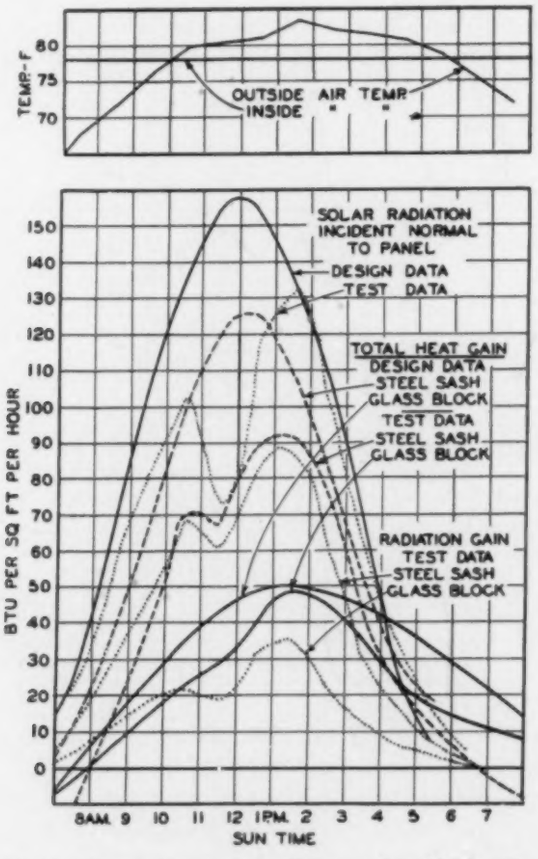


Fig. 8—Comparison between Type *A* glass block and single-glazed steel sash for both radiation and total heat gain on Aug. 25. Also shown are outside and inside temperatures for test day as well as design data for total heat gain through panels

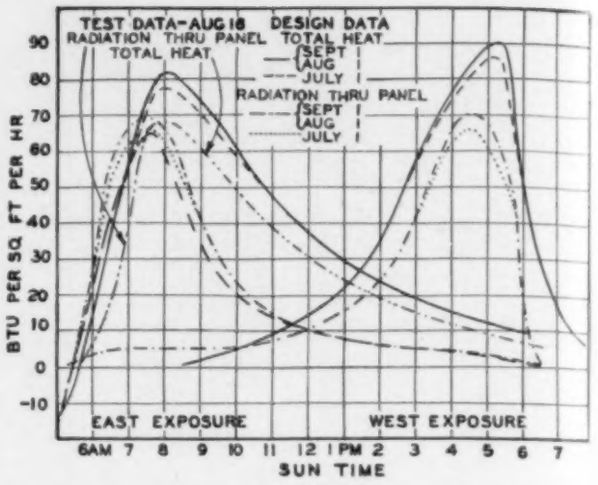


Fig. 9—Test data for Type *A* glass blocks with east exposure for Aug. 16 with design data for these blocks for July, August and Sept. 1. Design data for Type *A* block with west exposure are also given

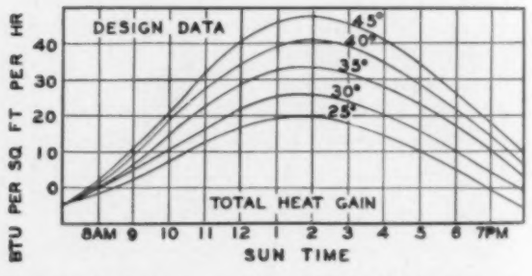


Fig. 10—Design curves giving total heat gain through Type *A* glass block panel facing south for Aug. 1 at north latitudes indicated

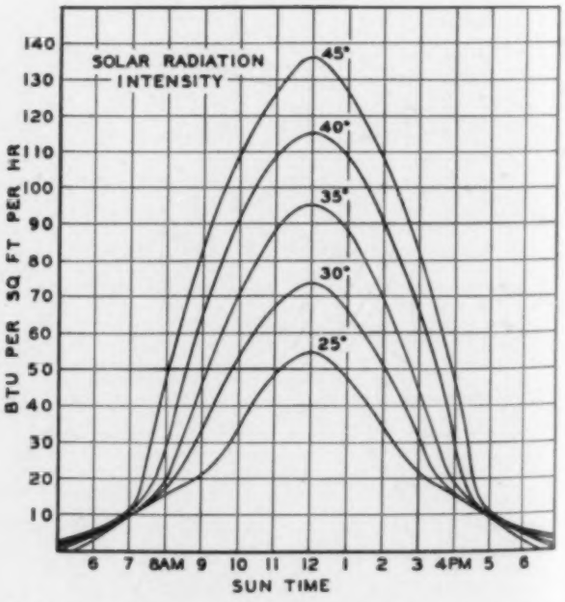


Fig. 11—Design curves for solar radiation intensity impinging on south wall for Aug. 1 at north latitudes of 25, 30, 35, 40 and 45 deg

total gain and radiation gain or the inside film transmittance, and finally, the total heat gain. In each chart the light-weight curves represent the actual observed values for the individual tests on the two Type *A* panels for the three days, August 10, 11 and 14. The heavy-line curves are given as representative maximums more or less determined as the upper envelope of the curves representing the test data. These average maximum curves were considered as representing the effect of the maximum outside air temperature and the sun radiation observed for the several tests. For comparison there are also plotted in this figure curves for suggested design radiation normal to a south wall for July 1, August 1 and September 1. It will be noted that the average curve used, which may be assumed to apply on August 12, fits very well into the series of design curves. The probable outside air temperature curve for a day in mid-summer, when the maximum reaches 95 F, is also plotted for comparison. It will be noted that this curve which may be accepted as a design temperature curve for Pittsburgh and many other metropolitan districts shows considerably higher temperatures than those observed.

As a result of observations of scattered radiation coming from parts of the sky other than the sun, made during the past summer by the Detroit Edison Co., and verified by work at the Laboratory and the literature,[4] and certain deductions, a series of curves giving suggested design solar radiation normal to a south window were developed; these are superimposed on the observed *solar radiation* chart, Fig. 4. Using these design solar radiation curves as a basis, and the percentages which, radiation through the glass, transmittance from the inside surface of the glass and total gain through the glass were, of the observed radiation normal to the outside surface of the glass, design curves for heat gain through Type *A* glass blocks on July, August and September first are given in Fig. 5.

The transmittance and total heat gain curves are corrected for increased transmittance from the outside air to the inside air based upon the design outside air temperature curve, Fig. 4. In this figure is given also the outside air to inside air conductance for the observed day as well as that for a 95 F day based upon an air to air transmittance coefficient, *U*, of 0.50 for a 15 mph wind. The difference between these two curves represented the amount added to the transmittance gain from the inside surface curves in order to correct them for a design outside temperature cycle on a day having a 95 F maximum.

Since the total heat gain curves in Fig. 5 represent the sum of the radiation gain and the transmittance gain from the inside surface, they also include this addition. It is of interest to note the small factor which outside to inside air transmittance is of the total gain through glass block construction when sun radiation is a factor. For convenience the actual curves based upon test data for about August 12 are included. Transmittance from the inside surface and total gain are also shown increased by an amount assumed to represent the added gain due to the outside temperature on a normal 95 F day with a 15 mph wind. It will be observed that the curves, *Test data*, corrected for a 95 F day fall in approximately the proper location with respect to the design curves for August 1 and September 1.

Calculations similar to those made for *A* glass were carried out for the other types of blocks with the results shown in Figs. 6 and 7. It will be noticed that these curves all show the same characteristic shape and that they do not differ greatly from one another in magnitude. A comparison of the design heat gain data for the three types of glass block studied for August first at the latitude of Pittsburgh is included in Table 1.

In order to determine the effect of outside shading on the total heat gain through glass blocks, a test was run on August 21 during which one of the glass block panels was completely shaded from the sun with two separated thicknesses of canvas. The total heat passing through the shaded panel between 9 a. m. and 5 p. m. amounted to 17 per cent of that passing through the unshaded panel, while the maximum rate of heat gain through the shaded panel was 13.5 per cent of that through the unshaded one.

A test was made on August 23 during which one of the panels was shaded with an inside Venetian blind having the slats set at a 45-deg angle so as to exclude direct radiation as was done in the previous Laboratory study.[5] This reduced the total heat admitted to 70 per cent and the maximum rate of heat gain to 66 per cent of that entering through the unshaded control panel.

On August 25 a direct comparison between one of the type *A* block panels and a single glazed steel sash was obtained. The results are shown in Fig. 8. It will be seen that for the actual test conditions a maximum of 94 per cent more heat entered the room containing the steel sash while for a design solar radiation and air temperature day this percentage was 147 per cent.

Two tests were made with the *A* glass panels facing east and one with these panels facing west. The test data for the east window, including total heat gain and radiation gain, are shown in Fig. 9, together with the design curves for July, August and September first. The design curves for the total heat gain and radiation gain through a type *A* glass panel facing west are also included in this figure. In the design curves shown for both the east and west tests one curve applies to July first while the other applies to both August and September first. This results from the fact that the solar intensity impinging on east and west surfaces varies by only 2½ per cent from August first to September first. Another feature which distinguishes these curves from those pertaining to a south wall is the fact that, whereas the south wall data are applicable only to the latitude of Pittsburgh (41 deg North) the east and west data apply to all latitudes between 30 deg north and 45 deg north with an accuracy of 0.5 per cent.

The approximate manner in which the variation in the total heat gain through type *A* glass blocks facing south depends on the latitude is shown in Fig. 10 which gives this gain through such a panel on August first at the different latitudes. These curves are based on the design solar radiation curves, Fig. 11, and a 95 F day. They were extrapolated from the data in the same manner as those for July first, August first and September first (Fig. 5), using the solar intensity curves of Fig. 11. It

[4]The Brightness of the Sky, by A. F. Moore and L. H. Abbot. (*Smithsonian Miscellaneous Collections*, Vol. 71, No. 4, Feb. 4, 1920).

[5]Loc. Cit. See Note 1.

might be suggested that because of the greater range of extrapolation in deriving the design data for a 25 deg latitude from test data in Pittsburgh compared with the smaller range of extrapolation used in obtaining design data for different months, there is some question concerning the acceptability of the curves of Fig. 10. It is suggested that further work be carried out to increase the confidence with which these results may be accepted.

In offering this report the authors wish to point out the obvious fact that over a period of one season it is impossible to complete all of the work which must be done before a complete understanding of all the phases of the subject can be had. Consequently, this work will be carried on over a number of years.

Acknowledgment

This paper reports the results of an investigation organized and carried out under the Technical Advisory Committee on Air Conditioning Requirements of Glass, consisting of the following: M. L. Carr, *chairman;* F. A. Bishop, W. A. Danielson, H. C. Dickinson, J. E. Frazier, S. O. Hall, E. H. Hobbie, C. L. Kribs, Jr., R. A. Miller, F. W. Parkinson, J. H. Plummer, W. C. Randall, L. T. Sherwood, J. T. Staples, G. B. Watkins and F. C. Weinert.

Acknowledgment is also made of the valuable assistance rendered by the Pittsburgh Corning Corp., and the Owens-Illinois Glass Co., in making the study possible through financial support and close cooperation in carrying on the work.

Research Activities

Notification letters have just been released by A. E. Stacey, Jr., New York, chairman of the Committee on Research, to 256 individuals advising them of their appointment to serve on the 21 various technical advisory committees. These committees perform a major function in the Society research program, as they are responsible for outlining the scope of investigation and share responsibility in supervising the work done at the Pittsburgh Research Laboratory and in the 11 cooperative institutions.

Negotiations are progressing in the establishment of a cooperative agreement with Rensselaer Polytechnic Institute, Troy, N. Y., to conduct experimental work on the transmission of sound through various types of duct systems. The program of investigation was outlined by the Research Technical Advisory Committee on Sound Control of which J. S. Parkinson, Manville, N. J., is chairman, and other members of the committee are: C. M. Ashley, Syracuse, N. Y.; A. L. Kimball, Schenectady, N. Y.; V. O. Knudsen, Los Angeles, Calif.; R. F. Norris, Madison, Wis.; C. H. Randolph, Milwaukee, Wis.; A. E. Stacey, Jr. and G. T. Stanton, New York, N. Y.; and R. M. Watt, Jr., Washington, D. C.

Guide Committee Meets

Comprehensive editorial plans for developing the 1941 edition of THE GUIDE were discussed at a meeting of the Guide Publication Committee held in New York City, March 9, with the following members in attendance: S. S. Sanford, *chairman*, Detroit, Mich.; P. D. Close, Chicago, Ill.; C. M. Humphreys, Pittsburgh, Pa.; and A. J. Offner, New York, N. Y.

It was reported that favorable comment had been expressed regarding the reduction in size of the 1940 edition, due to condensation and consolidation of text matter and the use of lighter weight paper. It was agreed for the future to continue the policy of presenting as small a size book as possible.

A cover design for the next edition was adopted and consideration was given to sectionalizing the technical data for ease in locating material.

Plans were developed for including in the next revision a chapter on Transportation Air Conditioning, which would not only cover railway applications but also buses, automobiles, ships and airplanes. The decision was also made to locate in a single chapter all information pertaining to refrigeration as differentiated from cooling and dehumidification methods.

Chapters which are scheduled for major revision in 1941 include: Refrigerants and Air Drying Agents; Heating Load; Chimneys and Draft Calculations; Automatic Fuel Burning Equipment; Cooling and Dehumidification Methods; Spray Equipment; Fans; Air Distribution; Air Duct Design; Sound Control; Industrial Air Conditioning; Automatic Control; Electrical Heating; Water Supply Piping and Water Heating; and two new chapters covering Transportation Air Conditioning and Refrigeration.

New Mechanical Engineering Building Discussed for Minnesota

March 11, 1940. Pres. F. C. Winterer called the meeting of the Minnesota Chapter to order at 7:30 p.m., and the minutes of the previous meeting were read and approved.

Prof. A. B. Algren, chapter delegate to the Society's 46th Annual Meeting in Cleveland, was then called upon to give his report of the meeting of chapter delegates. Vice-Pres. M. H. Bjerken discussed Professor Algren's report with the result that it was moved and seconded that the Minnesota Chapter adopt the policy of rotation of the membership committee as outlined at the delegates' meeting.

After some discussion it was moved by Professor Algren and seconded by H. E. Gerrish that the Minnesota Chapter contribute $25.00 toward the publication of a booklet for the promotion of a new Mechanical Engineering Building for the University of Minnesota, and the motion was carried.

The meeting was then turned over to L. C. Gross, who introduced the speaker of the evening, J. E. Haines, Minneapolis-Honeywell Regulator Co., who spoke on temperature control of zone systems. Mr. Haines illustrated and described the various methods of attaining zone control and demonstrated several devices developed by the company. His talk was very interesting and ended in a standing vote of thanks by the chapter. The meeting adjourned at 9:15 p.m.

Pittsburgh Conducts Tour of ASHVE Research Laboratory

March 11, 1940. For the March meeting the members and guests of the Pittsburgh Chapter met at the Fairfax Hotel for dinner, and immediately after the group proceeded to the auditorium of the Pittsburgh Experiment Station of the U. S. Bureau of Mines.

Pres. F. C. McIntosh dispensed with the minutes and other routine business and introduced F. C. Houghten, Director of the Society's Research Laboratory, who explained that the main purpose of the meeting was an inspection trip through the Laboratory. Before proceeding through the Laboratory, however, Mr. Houghten described the five projects which were being carried on at the Laboratory, on the subjects, effect of high effective temperatures on mental and physical efficiencies of workers, friction of air in ducts, heat transmission through various walls and roof constructions, the effect of radiation on comfort, and heat flow through glass brick.

The 48 members and guests present were divided into groups and conducted through the Laboratory by members of the staff, who explained in detail the test procedure and briefly discussed results obtained to date as each group arrived at the location of the project. Following an interesting inspection the meeting was adjourned at 11:00 p.m.

The Air-Cooled Human Body

By C.-E. A. Winslow,* (*MEMBER*), New Haven, Conn.

THE poets have defined man in highly varied terms, ranging from *the interpreter of God,* and *a reasonable being* and *a thinking creature* through *a tool to buy and sell, an ape and an angel* to *a two-legged animal.* All these characteristics and many more may be justified. In the booth of the Committee on the Hygiene of Housing at the New York World's Fair, one exhibit was entitled Man is a Heat Machine. This description is, perhaps, more fundamental than any of the others and is, at any rate, basic for the present discussion.

In the process of living the human body, like an automobile engine, produces heat by a process called metabolism and the amount of the heat which is produced varies very widely according to activity. The hourly heat produced in the body may be ten times as great when one exercises strenuously as when in bed and asleep.

The heat thus formed in the tissues must be balanced by an equivalent heat loss in order that the average temperature of the human body (98.6 F) may be constantly and uniformly maintained. Again, as in the case of the automobile, there must be provided a delicately adjusted cooling system but one which must be regulated much more closely than that of the car. If heat loss from the body is too rapid the tissues become chilled and ultimately, on prolonged exposure to severe cold, the processes of life are no longer possible, and death ensues. At the other extreme, if more heat is formed than can be carried away, the body temperature rises to a state of artificial fever, perhaps to 110 F, and at that extreme, too, fatal results ensue. In the early days of steamships, deaths from heat stroke among stokers were by no means a rare occurrence.

Under less extreme conditions, however, bodies have a remarkably efficient system for the regulation of heat production and heat loss. In a middle range (say between 68 F and 78 F) where normal metabolism and heat loss balance, such regulation is easy, and in this zone with slight and automatic changes in the distribution of blood between the skin and the interior organs, comfort is experienced and efficiency is high. Above 80 F, where the environment becomes too hot, the body brings into play a new factor of heat regulation by the discharge of sweat which evaporates and in the process of evaporation cools the surfaces of the body. For moderately hot conditions a remarkably perfect balance is thus obtained, although the condition is not an altogether comfortable one. On the other hand, when environmental conditions remove heat too rapidly, say below 65 F, the body adapts itself in some degree by narrowing the blood vessels of the skin and thus decreasing the amount of hot blood near the surface of the body, and thus reducing the amount of heat lost to the outer air. Where this process proves inadequate another sort of adaptation is accomplished by increasing heat production within the tissues; one tends to walk about and slap his breasts, which automatically increases heat production within the body through the vigorous exercise of the muscles.

It is important to remember, however, that the comfort zone of ideal temperature is by no means a fixed and definite one. A desirable environment depends directly upon the heat produced within the body and this varies with activity. Thus, for the lightly clothed subject in a semi-reclining position an air temperature of 80 F is desirable. In factories where light work is performed in summer time, 76 F has been found to be desirable. For children (who have a higher rate of metabolism than adults) 68 F to 70 F has been found correct in the school room, while in a gymnasium, 55 F is the desirable temperature.

For simplicity only air temperature has been spoken of. It is important to remember, however, that air temperature is only one of four distinct factors which govern heat loss from the body. Air movement is of major importance in increasing the cooling effect of air temperature, and when the atmosphere is hot the relative humidity of the air is of great importance, since, the more humid the air conditions, the more difficult it will be for the body to keep cool by the evaporation of sweat. Finally, the human body is constantly receiving radiant heat through the atmosphere from hot surfaces (fireplace, stove, walls, etc.,) in its vicinity and is losing heat by radiation to cold surfaces such as windows. From experience at the Pierce Laboratory it has been found that reclining subjects were well adjusted and comfortable in air at 50 F if the surrounding walls had a temperature of 110 F. Consideration must be given then, in planning for air conditioning, to these four factors of air temperature, air movement, relative humidity, and temperature of radiating surfaces.

From a practical standpoint the object of air conditioning may be considered from two major angles—keeping warm in winter and keeping cool in summer. To solve these problems one should go back to the fundamental questions of selecting a site and choosing a general method of construction.

First of all, it is important to remember that the position of a building with respect to the sun is of vital importance with regard to the desirable absorption of radiant heat from the sun in winter and the desirable exclusion of radiant heat from the sun in summer. Fortunately, both these desirable ends can be attained by the same general orientation, since in winter the sun is low and a southern wall will receive maximum heat, while in summer the sun is high and exerts its main influence on the windows facing east in the morning and west in the afternoon. Henry Nichols Wright has recently shown that, in the vicinity of New York, effective sun heat on a wall facing south is almost five times as great in winter as in summer, but on a wall facing west-north-west it is six times as great in summer as in winter. He changed the orientation of the same one-

*Professor of Public Health, Yale University School of Medicine; Director, John B. Pierce Laboratory of Hygiene.

Presented at meeting of Cleveland Rotary Club, Cleveland, Ohio, January 25, 1940.

story house (in a laboratory model) from a position in which the principal rooms faced north west to a position in which these rooms (with re-arranged and slightly increased fenestration) faced south-southwest. This change decreased average summer sun-heat to one-ninth and increased average winter sun-heat to fourfold of its value with the original orientation.

The insulation of a home is another major factor in air conditioning which has, in recent years, come to receive increased attention. Results of an intensive study conducted by the Tennessee Valley Authority have shown that heating costs may be 50 per cent greater in an uninsulated as compared with a well insulated dwelling.

Finally, after due attention to orientation and insulation, we have three generally available systems of heating the dwelling. Pure convection heating involves the warming of a given room by air which has been brought to a high temperature at some central point. The hot-air furnace in the cellar is a device of this sort and is a direct descendant of a similar construction used by the ancient Romans called a hypocaust, and the complex modern air conditioning system is essentially similar though it ordinarily provides a larger supply of air at lower temperature and makes it possible to maintain air control at temperature extremes. The second mode of heating, which involves radiation plus convection, is accomplished by the use of a source of relatively high heat within the room itself. The stove is the simplest and cheapest form for the low-cost detached dwelling, while systems of hot water and steam heating are suitable for larger installations.

Even the best type of radiator gives off more than three-fourths of its heat in the convected form by warming the air which passes over it. If real radiant heating is desired, one must turn to a third method of heating by the use of hot water pipes, or radiators, or electric panels set in the walls or ceilings which heat the surfaces in question to a temperature of 85 F to 100 F. Under such a plan direct convection heating is reduced to a minimum. There is remarkable uniformity of temperature throughout a room, the floor-ceiling differential being 1 F-2 F instead of 10 F or more with high temperature free-standing radiators. This system has been extensively used in England, most commonly in public buildings, with the heating units in the rather high ceilings. It has seemed more logical in this country to use the lower section of the walls, and three installations of this type are now operating successfully in and near New Haven. Commercial heating units for this latter type of heating are not yet on the market in this country; but it seems possible to those who have studied it, that this plan may yet prove the pleasantest and perhaps most economical form of winter heating for residences.

So far only the problem of keeping the homes warm in winter has been considered. The converse problem of keeping them cool in summer is physiologically, perhaps, as important. It has been, on the whole, strangely neglected for it is generally assumed that man must be protected against the cold of January but that the heat of August is an inevitable dispensation of divine providence. Experience in the cooling of auditoriums and railroad trains indicates that such is not the case, and the cooling of residences is likely to have an important future.

The physiological responses of the body under conditions warmer than the optimum are quite different from those which are manifest in the cold zone. Here the major defense of the body is evaporation and, as has been seen, the secretion of sweat is delicately adjusted to maintain thermal equilibrium over a considerable range of environmental conditions. This type of adaptation, however, has a rather sharp upper limit beyond which the sweat runs off without evaporating and exerting its cooling effects upon the body surfaces. For the lightly clothed body, at rest in a semi-reclining position, this limit is reached at 127 F in perfectly dry air and at 77 F with air completely saturated with moisture.

In this zone the relative humidity of the atmosphere is of prime importance, along with air temperature, air movement, and wall temperature. There is no very practical method of cooling walls, but summer comfort can be promoted by modifying either one or the other three factors involved.

Increase of comfort by air movement can be effected in two ways. The first of these is promotion of natural circulation by cross or through ventilation; and here the architect is responsible for providing room planning and fenestration which will make such natural ventilation possible. Even in the lowest cost housing this should be considered as essential. The second mode of utilizing air movement for summer cooling is the use of electric fans within the room to create local drafts, which is merely a problem of equipment.

The control of air temperature and air humidity is a more complex matter and is generally to be attained by air conditioning systems which can only be installed in dwellings where expense is no consideration. There is, however, an interesting halfway procedure which has yielded excellent results. This consists in the installation of an exhaust fan in the attic, to be turned on coincidently with the opening of windows in the evening to draw in the cool night air.

Where a complete plenum system is installed, dehumidification of the air supply will go far to provide a comfortable atmosphere or, finally, the temperature of the air may be reduced to any desired degree. In connection with the latter procedure, one should note the danger of over-cooling. There can be no doubt that real injury to health must have resulted from the very sharp contrast between air conditioned trains and the outside atmosphere in the early days of this practice.

It must be clear from what has been said that the art of air conditioning is a complex one and that many alternative methods may be used under different conditions to produce desirable results.

In the ordinary dwelling the main factors to be considered are those already mentioned—keeping warm in winter and keeping cool in summer. In such a dwelling (aside from the provision of flues to eliminate gases produced by combustion) problems of the chemical purity of the air are relatively minor and can ordinarily be solved without special ventilating devices. A certain amount of air change is desirable to prevent the accumulation of body odors but such air changes need only amount to 10 cu ft per person per minute. With adequate air space, this rate of air change will be auto-

matically attained in cold weather by normal leakage through walls and ceilings of ordinary porosity and around doors and windows; while it can be easily secured in warm weather by the opening of windows. With a space allotment of 400 cu ft per person, only 1½ air changes per hour are necessary to provide 1 air change of 10 cu ft per minute. This space allotment is essential for other reasons. It is indicated by the space requirements of ordinary furniture with room to move about between and it is about the space needed in a two-bed sleeping room to avoid mouth spray infection. A report[1] on basic principles of healthful housing of the *American Public Health Association* points out that this standard of 400 cu ft applies to any occupied space. Where separate rooms are used for living and sleeping, the total for the functioning area of the dwelling should be 800 cu ft per person. Where the same room is used for both living and sleeping, the value should be at least 500 cu ft.

In the dwelling, then, no special provision is ordinarily needed for ventilation as distinct from heating. In larger rooms where more people congregate, such as school rooms, small offices, and workshops, the removal of the excess heat produced by the bodies of the occupants becomes a matter of importance. The amount of heat produced by the children in a school room is about equal to that which would be liberated by the burning of a candle on each desk. If a desirable room temperature is to be maintained there must, therefore, be means of eliminating the heated air and replacing it by cooler air. In the school room or other relatively small occupied spaces, this can be accomplished by the method known as window-gravity ventilation. In this system air is admitted at the windows over slanting deflectors to avoid drafts and this incoming air is tempered by a radiator placed beneath each window. Heated air is allowed to escape by a gravity duct opening from near the ceiling.

In still larger auditoriums where you may have 50 people or more in a given room such a procedure as that indicated can never be adequate to keep the middle of the room cool without producing undesirable drafts near the windows. Here mechanical ventilation is essential, and for any such occupied space one must provide fans which will introduce tempered (and if it is desirable, humidified or dehumidified) air. Sometimes this fresh air is supplied at the bottom of the room, as in many auditoriums, and the warm air is allowed to escape through gravity ducts near the ceiling. Even better, perhaps, though more costly is the plan used with such success in the Senate and House of Representatives at Washington, by which cool but tempered air with regulated humidity is admitted near the ceiling and warm air exhausted by special exhaust fans from the floor. The apparatus designed for such purposes has been developed to a high degree of precision and it is possible to maintain a room at any desired temperature, humidity, and air movement at any season of the year.

Where special toxic fumes or dusts are present, as in many industrial processes, special exhaust ventilation for the removal of such impurities may, of course, be essential. This is a special problem which is not being considered today. In general the objective of the most complex system of air conditioning, like that of the primitive stove, is to maintain a desirable rate of heat loss from the surfaces of the human body.

There are still many unsolved problems in this field. The American Society of Heating and Ventilating Engineers has, for many years, devoted an unusual degree of attention to the scientific advancement of this art with which its members deal. About one-half of the annual dues paid by each member is devoted to pure research conducted under the auspices of the Society and the amount of time devoted to such problems by members of the Research Committee of the Society is impressive. As far back as 1923 a special Research Laboratory was established in Pittsburgh, and from this Laboratory came the first modern analysis of the various atmospheric factors influencing human health and comfort. There are at present in operation 24 different technical advisory committees devoted to the study of such subjects as the relations of air conditions to human health and comfort; the use of atmospheric factors in the treatment of diseases; the problems of air conditioning in industry and the removal of atmospheric impurities from the air; to the influence of radiation factors upon comfort; to the design of air conditioning equipment; to factors concerned with summer cooling; to the efficiency of solid fuels in heating; to the friction of air in ducts; to the air conditioning requirements of glass; to the possibilities of insulation and sound control.

Progress of the past 25 years has been astonishing and the field is constantly broadening. Here, as in other fields of public health, one can no longer be satisfied with the avoidance of obviously harmful conditions. Health is a positive ideal, not merely the art of staying alive. One's aim should be efficiency and fullness and joy of living. One should not be content with air free from harmful dusts, fumes, and odors, and air which is warm enough to avoid chill and cool enough to avoid obvious discomfort and enervation. What one desires are atmospheric conditions which produce an active sense of physical well-being, such as is experienced on the mountain top or the sea beach. More fundamental studies of physiological reactions are needed before this is possible; but it is believed that we stand on the threshold of an era in air conditioning in which the pleasure of positive physical satisfaction, and not merely the avoidance of dangers to health, will be a primary objective.

[1]Healthful Housing, 2nd Edition (*American Public Health Association*, May, 1939).

Mayflower-Air Conditioners, Inc., Has New Vice-President

H. M. McGaughey, associated with the Kelvinator Division, Nash-Kelvinator Corp., Detroit, for the past 10 years, has been appointed vice-president of Mayflower-Air Conditioners, Inc., St. Paul, Minn., manufacturers of warm air heating equipment. He started with Kelvinator as branch manager for the St. Louis and Kansas City, Mo., district, in charge of refrigeration service for factory branch at these points, and was consultant on all commercial refrigeration engineering application. He later became manager of air conditioning installations and service at the factory, air conditioning applications manager, sales manager of air conditioning and automatic heating, and recently manager of commercial distributor sales.

Fairchild Aerial Surveys, Inc.

The Heart of the Nation

We Want You in Washington

MEMBERS of the Society will gather in Washington, D. C., for the 1940 Semi-Annual Meeting, June 17-19 at the Wardman Park Hotel. The local chapter members will be hosts and the committee on arrangements is planning a program that will appeal to members, their wives and children.

Washington and the surrounding country of the Old Dominion offers much of educational and historical interest to visitors. This meeting offers members and their families the unique combination of a visit to the nation's capital at one of the most delightful times of the year, an opportunity to see historic Virginia and the New York World's Fair all in one trip.

Schutz

Union Station

Underwood & Underwood

Lincoln Memorial

There is fine train service to Washington from all parts of the United States and all World's Fair tickets are honored via Washington in either direction. There are also many optional routes and stop-over privileges, about which local agents will gladly furnish information.

For those who motor there are fine roads to Washington from all points of the compass. En route members may visit Charlottesville, Monticello, Jamestown, Williamsburg, Yorktown, Natural Bridge, the Caverns and many other places of interest.

Colonial and other historic shrines are plentiful in and around Washington. The network of paved highways is well marked so that visitors can readily find points of special interest such as, Wakefield Washington's birthplace, Ashlawn the home of Monroe, Stratford the birthplace of Robert E. Lee, and many others.

A trip over the Skyline Drive is a fine adventure and a visit to some of the famous caverns is something to be remembered. Nine of the largest open to the public are: Battlefield Crystal, Melrose, Shenandoah, Dixie and Endless on Route 11; Luray on Route 211; Skyline on Route 12; Massanutten on Route 33 and Grand.

In Washington there are many monumental public buildings which every visitor wants to see, including the Capitol, Library of Congress, the White House, Supreme Court Building, Lincoln Memorial, Smithsonian Institution, Archives, Bureau of Printing and Engraving, and others.

Underwood & Underwood

The White House

The local committee is planning several tours of buildings and inspections of some of the outstanding air conditioning installations.

The location of the headquarters hotel, in a private park away from the downtown district, has many advantages as ample parking space is available for motorists, there are facilities for entertaining the children, an outdoor swimming pool, tennis courts, nearby golf courses and moderate rates.

The Wardman Park is operated on the European plan with single rates for room and bath $3.00 per day, double $5.00 per day (for two people) and small additional charge for children.

Chairman Urdahl announces that the committee is planning a special ladies' and children's entertainment program and several unique features in connection with the banquet. The Washington Chapter members want all their fellow members to come to the meeting June 17-19 for an enjoyable time at an ideal season of the year.

P. S.—Just a reminder—June weather in Washington is uniformly good despite the belief of many people that summer is uncomfortably hot—ask the man who lives there.

Committee on Arrangements

Semi-Annual Meeting—June 17-19, 1940
American Society of Heating and Ventilating Engineers
T. H. Urdahl, *Chairman*

TECHNICAL SESSIONS—R. K. Thulman, *Chairman.*
INSPECTION TRIPS—S. P. Eagleton, *Chairman.*
TRANSPORTATION—D. B. Tuxhorn, *Chairman.*
REGISTRATION-RECEPTION—S. L. Gregg, *Chairman.*
PUBLICITY—M. T. Firestone, *Chairman.*
ATTENDANCE—W. H. Littleford, *Chairman.*
ENTERTAINMENT—I. M. Day, *Chairman.*
FISHING—Col. H. H. Downes, *Chairman.*
FINANCE—G. R. Walz, *Chairman.*
BANQUET—F. E. Spurney, *Chairman.*
GOLF—W. E. Kingswell, *Chairman.*
SIGHTSEEING—P. H. Erisman, Jr., *Chairman.*
LADIES—P. H. Loughran, Jr., *Chairman.*

Air Raid Shelters Discussed at Toronto

March 4, 1940. The regular monthly meeting of the Ontario Chapter was held at the Royal York Hotel, Toronto, with 49 members and guests in attendance.

Following dinner, Pres. H. D. Henion announced that the minutes of the preceding meeting would be accepted as written, and then called upon the principal speaker of the evening, C. Tasker, Toronto, who delivered an interesting talk on Air Raid Shelters. Mr. Tasker showed several slides of the various types of shelter construction and presented data which had been collected as to the air conditions in the shelters after being occupied over a period of time, which proved of interest to all. A lively discussion followed, and D. O. Price extended a vote of thanks to Mr. Tasker on behalf of the chapter for his splendid talk, which was followed by adjournment.

Hospital Air Conditioning and Low-Cost Housing Topics at Massachusetts Meetings

February 20, 1940. The February meeting of the Massachusetts Chapter was held at the Massachusetts Institute of Technology with 20 members and guests in attendance. Due to weather conditions the attendance did not reach the usual high mark.

C. F. Neergaard, consulting engineer in hospital planning, organization and management, New York City, was the guest of the evening. Mr. Neergaard gave an interesting talk, which had been well prepared, and which he delivered in a manner interesting to all. He discussed the advantages and limitations of hospital air conditioning from the viewpoint of the surgeon, the manufacturers of equipment, the consulting engineer, and the hospital operating engineer.

Considerable discussion followed and questions were answered by Mr. Neergaard.

Pres. H. C. Moore spoke briefly on some of the important papers presented at the Society's Annual Meeting in Cleveland, and, according to the secretary's report, the meeting adjourned following President Moore's discussion on the various technical papers.

January 16, 1940. The regular monthly meeting was held at the Massachusetts Institute of Technology with an attendance of 90 members and guests.

R. K. Thulman, mechanical engineer, Federal Housing Administration, Washington, D. C., gave an interesting presentation on low-cost construction with particular reference to methods of heating. He illustrated his talk with lantern slides, and a technicolor film entitled, Homes of Today. A lively discussion followed Mr. Thulman's address pertaining to construction details and advantages and limitations of various types of heating systems, after which the meeting was adjourned.

Air Conditioning in Field of Medicine— Dr. Ferderber's Topic at Michigan

February 19, 1940. The regular monthly meeting of the Michigan Chapter was held at Huyler's L'Aiglon, with 52 members and guests in attendance. Immediately following dinner the meeting was called to order by Pres. W. C. Randall, who introduced to the members and guests the 10 past presidents of the Michigan Chapter who were present.

Reports of the secretary and treasurer were read and approved, and Vice-Pres. G. H. Tuttle announced that the March meeting would be a joint meeting with the *American Society of Mechanical Engineers* and *National Warm Air Heating and Air Conditioning Association*. He further announced that the annual dinner-dance would be held at Dearborn Inn, April 20, 1940.

President Randall then introduced Dr. M. B. Ferderber, Fellow of Dept. of Industrial Hygiene, University of Pittsburgh, whose visit to Michigan was arranged by the Speaker's Bureau of the Society. Dr. Ferderber gave an interesting talk on the practical application of air conditioning in the field of medicine. Several men in the medical profession discussed certain phases of Dr. Ferderber's talk, and a general discussion followed in which Messrs. Spurgeon, Shea, Mabley, Burch, Harrigan, and Dr. Delaney, Ford Hospital, took part.

The meeting was concluded at 10:00 p. m., with a rising vote of thanks to the speaker.

Minnesota Welcomes John James

February 12, 1940. For the February meeting 36 members and guests of Minnesota Chapter gathered for dinner preceding the meeting at Minnesota Union.

The meeting was called to order by Pres. F. C. Winterer, and the minutes of the January meeting were read and approved. It was also announced at this time that Neil D. Adams was appointed chairman of the Membership Committee of the Society. A letter from Mr. Adams suggested that the chapter consider forming a student chapter at the University of Minnesota.

John R. Hall, Jr., chairman of the membership committee of the chapter, sent a letter announcing his acceptance of a position with the DeVilbiss Co., Toledo, Ohio, and expressed his regrets at having to leave Minnesota. It was unanimous that Mr. Hall's presence would be missed a great deal, and the chapter extended its best wishes for his success in his new position.

R. E. Backstrom gave a brief resumé of happenings at the 46th Annual Meeting in Cleveland, and on motion, duly seconded and passed, the report of Prof. A. B. Algren, delegate from the Chapter to Cleveland, was deferred until the March meeting of the officers and executive board of the Chapter.

At the request of President Winterer, Mr. Backstrom then introduced the guest of the evening, John James, New York, technical secretary of the Society, whose subject was What Research Means to Better Comfort, Efficiency and Health. Mr. James gave an excellent presentation of his subject, according to H. M. Betts, secretary of the Minnesota Chapter. He reviewed the research activities of the Society, both at the Research Laboratory, Pittsburgh, and at the various cooperating institutions throughout the United States, emphasizing the importance of correlating the results of this research and putting them to practical use in THE GUIDE.

Following an interesting discussion, a rising vote of thanks was extended Mr. James, which was followed by adjournment.

J. R. Vernon Visits Western New York

February 12, 1940. The Western New York Chapter of the Society held its regular monthly meeting at the University Club, with an attendance of 54 members and guests.

The minutes of the December meeting were read and approved. Pres. L. P. Saunders expressed his appreciation for the effort put forth by C. W. Farrar in arranging for the 56 members who left in a special car to attend the 46th Annual Meeting in Cleveland, which was the largest number of Western New York Chapter members that ever attended an annual meeting, as a group. He also expressed his gratitude to the members for their attendance.

B. C. Candee responded in connection with a communication received from the Rochester Convention and Publicity Bureau in regard to welcoming and entertaining the Chapter in Rochester. Roswell Farnham suggested that it be deferred temporarily, and it was moved and seconded that it be referred to the officers for discussion.

Following a report on the membership, Mr. Candee presented the treasurer's report, both of which were regularly approved. President Saunders announced that the speaker at the March meeting would be Prof. F. J. Linsenmeyer, head of department

of mechanical engineering, University of Detroit, whose subject would be Air Leakage through Full Metal Window Strips.

D. J. Mahoney then introduced the speaker, J. R. Vernon, Johnson Service Co., Chicago, who chose as his subject, Automatic Temperature Control for Air Conditioning Systems. He gave a very interesting and instructive talk which he accompanied by lantern slides. Following the discussion Mr. Mahoney introduced Potter Bowles, Stamford, Conn., A. F. H. Scott, New York, and B. M. Conaty, Buffalo. After a rising vote of thanks was given Mr. Vernon the meeting was adjourned.

Use of Potentiometer Discussed at Western Michigan

February 12, 1940. The February meeting of the Western Michigan Chapter was held in the Mechanical Engineering Laboratories at Michigan State College, East Lansing, with an attendance of 82 members and guests.

Pres. B. F. McLouth called the meeting to order and the minutes of the January meeting were read and approved. President McLouth then introduced Dean Dirks, Michigan State College, who acted as chairman for the evening, and who in turn introduced Mr. Gneiser, Leeds and Northrup Co., who gave a discussion on the use of the potentiometer and various thermocouples in temperature measurements. Mr. Gneiser also gave diagrams showing how the most common instruments were constructed.

Prof. C. H. Pesterfield, secretary of the chapter, was then introduced and gave a short discussion on soil temperature research now being conducted at the college.

Prof. W. E. Reuling was the next to be introduced by Dean Dirks, and he furnished his audience with considerable entertainment for the remainder of the evening in his novel demonstrations in friction loss in fluid flow. The meeting adjourned at 10:30 p.m.

John James Addresses Manitoba

February 9, 1940. A dinner meeting of the Manitoba Chapter was held at the Fort Garry Hotel, Winnipeg, with Pres. G. C. Davis presiding. The guest speaker of the evening was John James, New York, Technical Secretary of the ASHVE.

The minutes of the previous meeting were read and approved, and the secretary read a letter from the New York office, advising that any member joining the armed forces in Canada would have his name placed on a special service roll until his release from service. The secretary was then requested to advise the headquarters' office that P. H. Foster had already joined the Air Force.

President Davis discussed a letter from Neil D. Adams, relative to a proposed talk by Dr. Charles Sheard, Rochester, Minn., and instructed the secretary to advise Mr. Adams that the Chapter would be pleased to hold a meeting on the date specified, and it was suggested that some of the medical profession be urged to attend.

D. Swayne spoke regarding a new proposed Engineers Club for Winnipeg and he was appointed delegate to attend the first meeting and to report at the next chapter meeting.

President Davis then introduced Mr. James, who addressed the meeting on the subject of What Research Means to Better Comfort, Efficiency and Health. Mr. James' talk proved most interesting and was greatly appreciated by the Manitoba members. Frank Thompson expressed the sincere thanks of the chapter to Mr. James for his excellent address, which was followed by adjournment at 10:30 p. m.

December 5, 1939. The monthly meeting of the Manitoba Chapter in December was also held at the Fort Garry Hotel, Winnipeg, with 20 members and guests in attendance. The meeting was called to order by President Davis, followed by the reading of the minutes held October 26, which were approved as read.

The secretary read two letters from the Society's headquarters' office, concerning the official delegates to the 46th Annual Meeting, Cleveland, and on motion by William Worton, seconded by R. L. Kent, President Davis was named as the official delegate and on further motion R. L. Kent was named as alternate.

P. L. Charles then introduced S. R. Lewis, Chicago, who gave a very interesting address on the subject of Troubles of an Air Conditioning Engineer. J. B. Steel expressed the appreciation of the Chapter to Mr. Lewis, and the meeting was adjourned at 10:00 p. m.

Howatt and Lewis Discuss Solar Radiation at Illinois Meeting

January 8, 1940. The first meeting of the year was held at the Merchants and Manufacturers Club with 69 members and guests present for dinner preceding the meeting with several more arriving later.

Pres. Tom Brown called the meeting to order, and requested the secretary to read the minutes of the December meeting. A. O. May reported for the membership committee, followed by an announcement that W. H. Driscoll, New York, would be the guest of the Illinois Chapter at its February meeting.

The meeting was then turned over to John Howatt and S. R. Lewis, who gave a preview of the paper entitled Heat Gain Through Glass Blocks by Solar Radiation and Transmittance which was scheduled for the 46th Annual Meeting of the Society in Cleveland.

Mr. Howatt opened the discussion with a general review of solar radiation, pointing out that radiation presents difficulties to the air conditioning engineer in maintaining comfortable conditions in summer and that new forms of construction, such as glass blocks, have been developed to help solve these problems. Following Mr. Howatt's presentation of the background of the subject, Mr. Lewis gave an abstract of the paper and showed slides of several of the curves developed from the test data. He analyzed and interpreted the information from the standpoint of the man in practice, and indicated its usefulness to the air conditioning profession. He completed his analysis of the paper by giving four specific conclusions, which he stressed were his own.

An interesting discussion followed and comments were offered by J. J. Aeberly, R. E. Hattis, A. G. Sutcliffe, I. E. Brooke, and Dr. W. P. Morrell, *American Medical Association.* Interest was shown in the use of ultraviolet lamps for killing bacteria in air in hospitals, and it was mentioned that a paper on this subject was also scheduled for the Cleveland Meeting. Following numerous questions the meeting was adjourned at 9:30 p. m.

Carnegie Students Meet

February 8, 1940. The Student Chapter of the Carnegie Institute of Technology held a joint meeting with the student chapter of the *ASME,* and G. W. Penney, Westinghouse Electric & Mfg. Co., E. Pittsburgh, was the speaker of the evening. Mr. Penney's subject dealt with the electric smoke precipitators, in which he brought out many practical points. He also pointed out that electric precipitating units were useful in the home as well as in industry. Following Mr. Penney's talk the meeting was adjourned.

January 9, 1940. The business meeting of the Carnegie Tech Student Chapter was called to order and the minutes of the previous meeting were read. Membership in the Student Chapter and in the Society was discussed, and according to the report by A. P. Sgambati, a motion was made to hold a party later in the month, which was duly seconded and passed. There being no further business the meeting was adjourned.

Apparatus Noise in Buildings Discussed at Philadelphia

February 8, 1940. The February meeting of the Philadelphia Chapter was held at the Engineers' Club with 65 members and guests present. The meeting was preceded by an address by Henry T. Dolan, who spoke in behalf of the united charities campaign, and another brief talk was given by Envoy Kenneth Noel of the Salvation Army.

The business meeting was called to order by Pres. R. F. Hunger, and the minutes of the January meeting were read and approved. The treasurer's report was read, and C. B. Eastman reported for the membership committee.

H. B. Hedges announced that W. H. Driscoll, New York, would be the speaker at the March meeting, and that the chapter will visit the Anthracite Industries Laboratory, Primos, Pa., in April.

Mr. Hedges then introduced the guest of the evening, T. A. Walters, research engineer, American Blower Corp., who discussed apparatus noise in buildings. Mr. Walters illustrated his talk with slides showing the various variables entering into the problem. Following a discussion on the subject the meeting adjourned at 10:10 p. m., according to Edwin Elliot, secretary of the chapter.

Oklahoma Chapter Hears Dr. Ferderber

February 7, 1940. The 32 members and guests of the Oklahoma Chapter who were in attendance for the February meeting enjoyed a very enlightening talk by Dr. M. B. Ferderber, Fellow of Department of Industrial Hygiene, University of Pittsburgh Medical School, whose subject was the Practical Application of Air Conditioning in the Field of Medicine. His talk was followed by a long and interesting discussion.

According to S. L. Rolland, secretary of the Oklahoma Chapter, it was the consensus of opinion that Dr. Ferderber's talk was one of the most informative talks given recently before the chapter, and his visit was thoroughly enjoyed by the members and guests present.

Oregon Chapter Welcomes James as Speaker

February 5, 1940. The February meeting of the Oregon Chapter was called to order by Pres. J. D. Kroeker with 73 members and guests present. President Kroeker gave a brief history of the Society and of the chapter and then introduced a few of the guests.

Prof. S. H. Graf, Oregon State College, was introduced by President Kroeker, and he in turn introduced the speaker of the evening, John James, technical secretary of the Society, and a graduate of Oregon State College. Mr. James delivered a very interesting address on What Research Means to Better Comfort, Efficiency and Health.

Following a lively discussion on various phases of Mr. James' subject, President Kroeker called on B. W. Farnes who reported for the Nominating Committee. The candidates are as follows: *President,* T. E. Taylor; *Vice-President,* J. F. McIndoe; *Treasurer,* C. M. MacGregor; *Secretary,* B. W. Moore, *Board of Governors,* J. A. Freeman, W. T. Finnigan and J. D. Kroeker.

Vice-President Taylor gave a preview of the topic for discussion at the March meeting, and also reported on the Society's 46th Annual Meeting in Cleveland.

E. C. Willey announced the Oregon State Air Conditioning Conference scheduled at Corvallis, March 28, 29 and 30, and with no further business to be discussed the meeting was adjourned.

January 4, 1940. Pres. J. D. Kroeker called the regular monthly meeting to order with 22 members and guests in attendance. The minutes of the December meeting were approved as read, and President Kroeker introduced Del Brown, Portland General Electric Co., who discussed efficiency measurement of small furnaces, which was followed by considerable discussion.

A report of the officers was called for, and the secretary reported on miscellaneous items. Announcement was then made of the appointment of President Kroeker as a representative on the Society's Nominating Committee, with E. C. Willey serving as alternate. It was also announced that E. E. Carroll would attend the Society's 46th Annual Meeting in Cleveland.

Prof. S. H. Graf, Oregon State College, gave a complete resumé of House Bill No. 4500. It was moved and seconded that the secretary write to the Congressmen asking their support of the bill. A copy of the bill was requested for presentation before the *Heating, Piping and Air Conditioning Contractors National Association* for their consideration.

Following the report by the Legislative Committee, B. W. Moore reported on the status of the membership in the chapter.

Mr. Willey as chairman of the Air Conditioning Conference Committee, announced the dates of the conference as March 28, 29 and 30, and also announced his committee appointments.

B. W. Farnes, chairman of the meetings committee then announced that John James, technical secretary of the Society, would be the guest at the February meeting, and that a report on the Annual Meeting would be given by T. E. Taylor at the March meeting. He further announced that it was planned to have Pres. F. E. Giesecke, College Station, Tex., attend the Air Conditioning Conference on March 29.

It was stated, according to C. E. Heinkel, secretary of the Chapter, that the public relations committee was working on outlines, and will contact the heads of community clubs for possible speaking dates.

Air Conditioning in Field of Medicine Discussed at St. Louis

February 6, 1940. The regular Chapter meeting was held at the David Ranken Jr. School of Mechanical Trades, with 47 members and guests in attendance. The secretary read the minutes of the previous meeting, which were approved as read.

Following the report of the treasurer, D. J. Fagin reported no new developments on the Smoke Committee. C. E. Hartwein made some interesting comments on the 46th Annual Meeting in Cleveland. W. A. Russell, Kansas City, was then introduced and announced that the 1941 Annual Meeting of the Society would be held in Kansas City. He suggested that members of the chapter be urged to prepare papers on subjects with which they were entirely familiar, and have them presented as part of the regular chapter program.

A motion was made and the chapter extended a vote of thanks to the David Ranken Jr. School for its hospitality, and the business meeting adjourned, followed by the regular meeting at which Dr. M. B. Ferderber, University of Pittsburgh, School of Medicine was the guest speaker. Dr. Ferderber spoke on the practical application of air conditioning in the field of medicine, presenting his subject most ably. Dr. Ferderber's visit was arranged through the courtesy of the Society's Speakers' Bureau.

Bureau of Standards Announces Simplified Practice Recommendation

The recently proposed Simplified Practice Recommendation for large tube cast-iron radiators has been accorded the required degree of acceptance by the industry, and has been approved for promulgation as of March 1, 1940, according to an announcement of the division of Simplified Practice, National Bureau of Standards. The recommendation will be identified as Simplified Practice Recommendation R174-40.

This recommendation, in the opinion of the sponsors, should reduce the cost of production and greatly facilitate the maintenance of adequate inventories of the recommended sizes. It should also simplify the work of engineers, architects, and contractors in specifying, procuring, and installing radiation, and simplify the problems of the distributors and jobbers by insuring more prompt deliveries.

CANDIDATES FOR MEMBERSHIP

The Constitution of the Society, as now amended, requires the following mode of procedure in voting on applicants for membership in the Society. All applications for membership are to be sent to the Secretary and the names of applicants and their references shall be printed in the next issue of the JOURNAL of the Society or sent to the members in other approved manner as ordered by the Council. When replies are received from references, the Candidate's application shall be submitted to and acted upon by the Committee on Admission and Advancement as soon as possible.

When the Committee on Admission and Advancement has acted favorably upon a Candidate's application and assigned his grade, the Council shall vote upon the election of the proposed Candidate for membership by letter ballot. During the past month 34 applications for membership have been received and the names of these men and their sponsors are published in the following list.

Members are requested to scrutinize the list with care. The Committee on Admission and Advancement, and in turn, the Council, urge the members to assume their share of responsibility of receiving these candidates into membership by advising the Secretary promptly of any whose eligibility for membership is in any way questioned.

All correspondence in regard to such matters is strictly confidential, and is solely for the good of the Society, which it is the duty of every member to promote.

Unless objection is made by some member by April 16, 1940, these candidates will be balloted upon by the Council. Those elected to membership will be notified by the Secretary immediately after election.

CANDIDATES	REFERENCES	
	Proposers	*Seconders*
BABER, J. E., Sales Engr., T. C. Heyward, Charlotte, N. C.	T. C. Cooke	H. H. Hill
BAKER, D. L., Sales Engr., Messrs. Martin & Co., Delhi, India	M. E. Barnard	L. L. Lewis
	H. S. Traynor	R. V. Dunne
BREYER, FREDERICK, Student, Carnegie Inst. of Tech., Pittsburgh, Pa.	Ledyard Avery	E. E. Cragg (*ASRE*)
	C. M. Humphreys	J. F. Collins, Jr.
BRUNNER, E. G., Burner Sales, Dome Oil Co., Inc., Washington, D. C.	T. F. Rockwell	P. A. Edwards
	R. H. Feltwell	S. L. Gregg
CUMMINGS, R. J., Engr. & Estimator, Franck & Fric, Cleveland, Ohio.	T. H. Urdahl	F. A. Leser
	B. F. McLouth	C. H. Pesterfield
DABBS, J. T., Chief Engr., Highland Technical School, Los Angeles, Calif.	L. G. Miller	L. E. Slawson
	H. M. Hendrickson	E. P. Wells
DAVIDSON, J. C., JR. Htg. & Air Cond. Engr., Dept. of Bldgs., City of Minneapolis, Minn. (*Advancement*)	Maron Kennedy	A. J. Hess
	H. M. Betts	A. B. Algren
DERER, BERNARD, Pres., Airo Contracting Co., Inc., Brooklyn, N. Y.	F. B. Rowley	C. E. Lund
	G. A. Belsky	J. A. Heller
EKLUND, G. P., Student, University of Minnesota, Minneapolis, Minn.	F. A. Waters	Bernard Leventhal
	F. B. Rowley	R. C. Jordan
ELY, R. S., Student, Michigan State College, East Lansing, Mich.	A. B. Algren	C. E. Lund
	L. G. Miller	R. E. Distel
FOOTE, J. H., JR., Student, Michigan State College, East Lansing, Mich.	C. H. Pesterfield	H. B. Dirks (*ASME*)
	L. G. Miller	R. E. Distel
GRITSCHKE, E. R., Cons. Engr., Chicago, Ill.	C. H. Pesterfield	B. F. McLouth
	M. W. Bishop	S. M. Trumbo
HERRE, H. A., Student, Carnegie Inst. of Tech., Pittsburgh, Pa.	B. A. Broom	H. J. Zack
	C. M. Humphreys	R. L. Smith
HORNE, H. F., Sales Engr., Johns-Manville Co., Washington, D. C.	T. F. Rockwell	D. C. Pugh
	J. H. Hanlein	M. F. Hoppe
INMAN, MACON, Supervising Engr., Cafritz Co., Washington, D. C.	T. H. Urdahl	F. A. Leser
	G. F. Miller	F. M. Thuney
JENKINS, S. D., Htg. Dept. Mgr., Bell & Morris, Calgary, Alta., Canada.	W. E. Kingswell	T. H. Urdahl
	A. H. Hills	E. J. Ritchie
JONES, H. S., Student, Carnegie Inst. of Tech., Pittsburgh, Pa.	G. H. Hopper	T. N. Adlam
	C. M. Humphreys	J. F. Collins, Jr.
JORDY, J. J., Engr. & Contractor, Jordy Bros., Inc., New Orleans, La.	T. F. Rockwell	P. A. Edwards
	I. H. Purinton	G. E. May
KELLY, J. J., Sales Engr., Philadelphia Elec. & Mfg. Co., Philadelphia, Pa.	John Devlin	F. G. Burns
	H. G. McCullough	H. H. Berry (*Non-Member*)
KELLY, O. A., Student, Michigan State College, East Lansing, Mich.	H. H. Mather	E. W. Seese (*Non-Member*)
	L. G. Miller	B. F. McLouth
LIERLICH, MURRAY, Student, Carnegie Inst. of Tech., Pittsburgh, Pa.	C. H. Pesterfield	H. B. Dirks (*ASME*)
	C. M. Humphreys	J. F. Collins, Jr.
LYNCH, J. R., Owner, Lynch Furnace Co., Portland, Ore.	T. F. Rockwell	P. A. Edwards
	B. W. Moore	E. C. Willey
MALIN, B. S., Mech. Inspector, U. S. Dept. of Agr., Peoria, Ill. (*Advancement*)	W. R. Burton	J. D. Kroeker
	B. E. Tiltz	James Holt
MERZ, R. A., Student, Michigan State College, East Lansing, Mich.	J. C. Rose	I. E. Shaer
	L. G. Miller	B. F. McLouth
MINKLER, W. A., Asst. Sales Mgr., Young Radiator Co., Racine, Wis.	C. H. Pesterfield	H. B. Dirks (*ASME*)
	M. F. May	J. H. Volk
MOORE, MACDONELL, Pres. & Gen. Mgr., The Moore Fuel Corp., Danbury, Conn.	A. S. Krenz	J. B. Banks
	C. P. Balsam	Arthur Frazee (*Non-Member*)
OBERLIN, J. A., Student, Michigan State College, East Lansing, Mich.	J. S. Cunningham	W. S. Allen (*Non-Member*)
	L. G. Miller	B. F. McLouth
PETERSON, D. J., Dist. Mgr., Minneapolis-Honeywell Reg. Co., Buffalo, N. Y.	C. H. Pesterfield	J. S. Cunningham
	C. W. Farrar	Roswell Farnham
PRAWL, F. E., Cons. Engr., Prawl Engineering Co., Scottsbluff, Nebr. (*Advancement*)	Herman Seelbach, Jr.	Joseph Davis
	W. M. Matthews	N. E. Schwartz
	M. M. Shapiro	B. L. Malcolm

STOTT, D. A., Mgr., Canadian Powers Reg. Co., Ltd., Toronto, Ont., Can.
STRAND, C. A., Supt., Bruce Wigle Co., Detroit, Mich.

WARREN, H. P., Lab. Asst., Texas Engrg. Experiment Station, College Station, Texas.
WINER, B. B., Student, Carnegie Inst. of Tech., Pittsburgh, Pa.

WOOTEN, M. F., JR., Cons. Engr., Charlotte, N. C.

H. D. Henion
M. W. Shears
J. S. Kilner
R. D. Randall
F. E. Giesecke
W. H. Badgett
C. M. Humphreys
T. F. Rockwell
C. E. Petty
P. L. Guest, Jr.

M. F. Thomas
H. R. Roth
W. H. Old
R. H. Oberschulte
W. E. Long
E. G. Smith
D. C. Pugh
R. L. Smith
H. H. Hill
E. R. Harding

CANDIDATES ELECTED

In the past issues of the JOURNAL of the Society the names of the following men were listed as Candidates for Membership. The membership grade of each Candidate has been assigned by the Committee on Admission and Advancement and balloted upon by the Council. We are now instructed by the Council to post herewith, as required by Art. B-III, Sec. 8, of the By-Laws, the following list of candidates elected:

MEMBERS

BAIRD, F. E., Dist. Mgr., The Trane Co., Atlanta, Ga. (*Reinstatement*)
BIBLE, H. U., Cons. Engr., Houston, Tex.
CAMPAU, W. R., Htg. Contractor, Kendall Heating Co., Portland, Ore.
CARTER, A. W., Htg. Engr., Monarch Brass Mfg. Co., Toronto, Ont., Can. (*Advancement*)
COLE, C. B., Contracting Engr., Boynton Cole & Co., Atlanta, Ga. (*Advancement*)
ESSEX, J. L., Engr., Armco International Corp., Middletown, Ohio.
GRANT, W. H., JR., Br. Mgr., Warren Webster & Co., New Orleans, La.
GUTKNECHT, FRITZ, Engr., Blattmann Weeser Sheet Metal Works, Inc., New Orleans, La.
HAINES, J. E., Mgr., Modutrol Div., Minneapolis-Honeywell Reg. Co., Minneapolis, Minn.
HERSHEY, A. E., Research Asst. Prof., Univ. of Illinois, Urbana, Ill.
HOLSWORTH, R. C., Mech. Cons. Engr., Corpus Christi, Tex.
JORDAN, R. C., Instructor Htg., Vtg. & Air Cond., Univ. of Minnesota, Minneapolis, Minn. (*Advancement*)
KLAGES, F. E. P., Dist. Mgr., The Powers Regulator Co., Greensboro, N. C.
LAIR, P. H., Cons. Engr., The P. H. Lair Associates, Boston, Mass.
MCGINNIS, F. L., Mech. Engr., Williamsburg Restoration, Inc., Williamsburg, Va.
MORRO, J. J., Engr. in Charge, Paragon Oil Burner Corp., New York, N. Y.
MUMFORD, A. R., Assoc. Dir. of Research, Consolidated Edison Co. of New York, New York, N. Y.
NORTON, J. A., Mgr. Htg. Section, Crane, Ltd., Toronto, Ont., Can.
OSTER, W. P., Vice-Pres., Equitable Equip. Co., Inc., New Orleans, La.
PULLUM, C. E., Vice-Pres., Bell & Gossett Co., Chicago, Ill.
RYAN, W. F., Sales Engr., The Salina Supply Co., Salina, Kans. (*Advancement*)
STANGLE, W. H., Special Engr., Servel, Inc., New York, N. Y.

ASSOCIATES

ALTEMUELLER, G. F., Chief Engr., Homeland Investment Co., Durham, N. C.
BARNES, N. W., Dist. Sales Mgr., The Fulton Sylphon Co., Chicago, Ill.
BLUM, R. J., JR., Sales Engr., The Kirk & Blum Mfg. Co., Cincinnati, Ohio.
BOWES, W. H., Sales Engr., Canadian General Elec. Co., Ltd., Toronto, Ont., Can.
CHASE, P. S., Plbg., Htg., Vtg. & Air Cond., Chase Co., Eugene, Ore.
COLMAN, R. C., Vice-Pres., McQuay, Inc., Minneapolis, Minn.
CRARY, J. O., Mgr. Air Cond. & Comm. Dept., Frigidaire Div., General Motors Sales Corp., New Orleans, La.
FISCHER, F. P., Gas Sales Engr., Frank P. Fischer Engrg. Co., New Orleans, La.
GUILBERT, S. R., Air Cond. Sales Engr., The Riester-Thesmacher Co., Cleveland, Ohio.
HAMILTON, H. S., Gen. Mgr. & Dir. of Sales, Air Correction Co., Milwaukee, Wis.
HEAGERTY, W. H., Sales Engr., William H. Heagerty Co., Washington, D. C. (*Reinstatement*)
JUERGENS, W. A., Sales Engr., John P. Childe Co., Cincinnati, Ohio.
KING, R. W., Sales Engr., Asbestos Covering & Roofing Co., Washington, D. C.
KIRTLAND, E. M., Dist. Repr., Mueller Brass Co., Milwaukee, Wis.
MOLLANDER, E. D., Dir., Register & Grille Mfg. Co., Inc., Brooklyn, N. Y.
MYER, HAYDN, Pres., Haydn Myer Co., Inc., Birmingham, Ala. (*Reinstatement*)
NORTH, W. R., Sales Engr., Baltimore, Md.
ORMISTON, J. B., Owner, Ormiston Plbg. Htg. Co., Yonkers, N. Y.
PARKINSON, J. S., Acoustical Engr., Johns-Manville Research Labs., Manville, N. J.
REPP, H. L., Br. Mgr., U. S. Radiator Corp., Cleveland, Ohio (*Reinstatement*)
RESCH, R. J., Pres., McQuay, Inc., Minneapolis, Minn.
SNOOK, A. H., Mfrs. Agent, Kalamazoo, Mich.
VAN WYNGARDEN, J. E., Mgr., Day Heating Co., Salem, Ore.

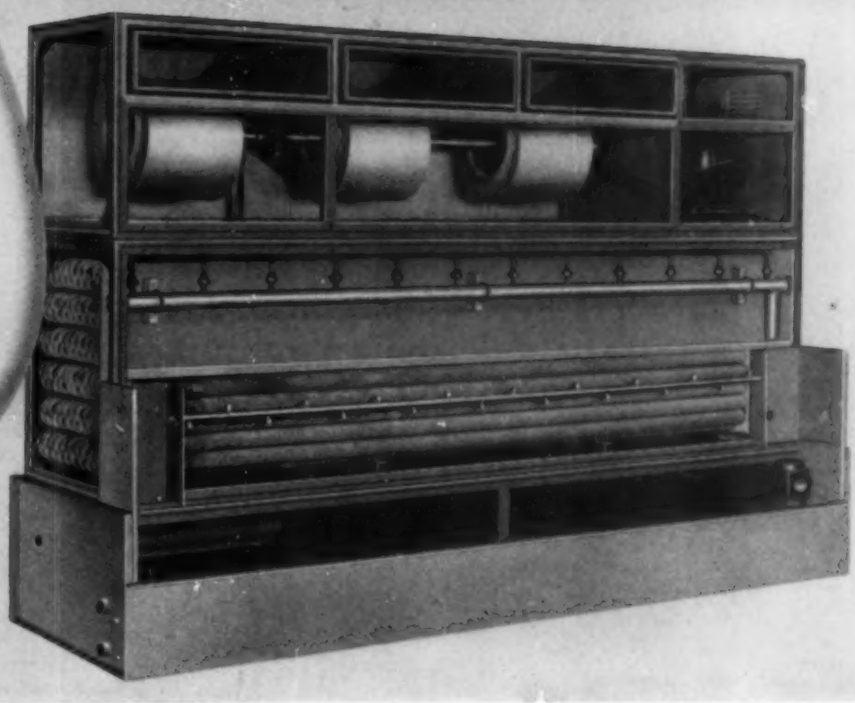
JUNIORS

BRUNDAGE, F. W., Mech. Engr., Stewart-Kingscott Co., Kalamazoo, Mich.
CONKLIN, R. M., Engr., The Fred D. Pfening Co., Columbus, Ohio
EDER, J. P., Development of Htg. Controls, Walker & Eder, New York, N. Y.
FLUCKEY, K. N., Lab. Asst., Washington Gas Light Co., Washington, D. C.
HERBERT, J. S., Asst. Engr. & Sales Engr., Blue Ridge Glass Corp., Kingsport, Tenn.
HOOVER, W. L., Sales Engr., Clarage Fan Co., Washington, D. C.
MEHMKEN, H. O., Engr., York Ice Machy. Corp., St. Louis, Mo.
PAULEY, R. D., Development Engr., Wood Conversion Co., Cloquet, Minn.
POUGHER, P. R. E., Engr., Ernest W. Pougher & Son, Manchester, England
RAINSON, SAMUEL, Htg. Vtg. & Cooling Mechanic, Great Neck, L. I., N. Y.
SPELBRINK, R. G., Office Engr., York Ice Machy. Corp., St. Louis, Mo.
THEISS, E. S., Instructor Mech. Engrg., Duke Univ., Durham, N. C.
WEISS, W. G., Sales Mgr., St. Louis Furnace Mfg. Co., St. Louis, Mo.

STUDENTS

BROWN, L. S., Jr., Student, Catholic Univ. of America, Washington, D. C.
GEBEL, K. M., Student, City College of New York School of Tech., New York, N. Y.
GOLDMANN, PHILIPP, Student, Catholic Univ. of America, Washington, D. C.
LEMBERGER, E. B., Student, Massachusetts Institute of Technology, Cambridge, Mass.
MCCUSKER, J. P., Student, Catholic University of America, Washington, D. C.
STAUFFER, J. E., Student, Carnegie Institute of Technology, Pittsburgh, Pa.

A DROP IN THE BUCKET!



York Economizer with liquid sub-cooling coil.

DON'T let condenser water problems stand in your way. If water rates are high, if the supply is limited, the York Economizer is the answer. It saves 99 per cent of the city water normally required for a refrigerating system. Compared with recirculation in cooling towers, the York Economizer means approximately 97 per cent saving in pumping power.

Built to take care of both large and small jobs, these York Economizers are of sectional design for easy transportation and assembly, are quickly and easily opened for inspection by removing the panels.

The condenser element of bare pipe welded into a unit and galvanized after fabrication, presents no cleaning problem. Non-ferrous coils are available where specified. A low-head, direct-connected pump handles circulation over the condenser from the float-controlled make-up pan in the unit base. No eliminators being required, fan resistance and power needs are reduced.

Check over the York Economizer point by point. You'll find maximum condensing effect in minimum space. Look in your classified phone book for the York trade-mark.

York Ice Machinery Corporation, York, Penna. Headquarters Branches and Distributors throughout the world.

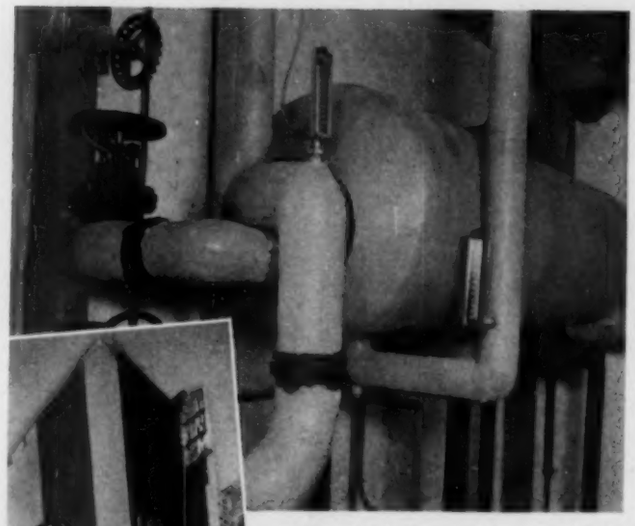
york refrigeration air conditioning

Headquarters for Mechanical Cooling Since 1885

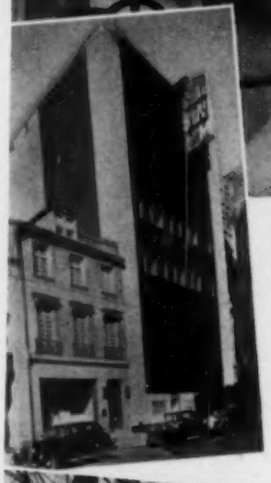
See the latest York equipment at the showroom of the York Branch or Distributor nearest you

Refrigeration and Air Conditioning for every Industrial Application • Comfort Air Conditioning for every type of Store, Restaurant, Office, Hotel, Institution or Residence • Marine Refrigeration and Air Conditioning • Yorkaire Automatic Heating • Refrigeration for every Commercial Use; Hotel and Restaurant Refrigerators; Beverage Dispensing Equipment • FlakIce Machine — Ribbon Ice in 60 Seconds • Dairy and Ice Cream Plant Equipment • Refrigeration Accessories and Supplies.

If you want clean hot water forever buy *Whitlock* Everdur Heaters



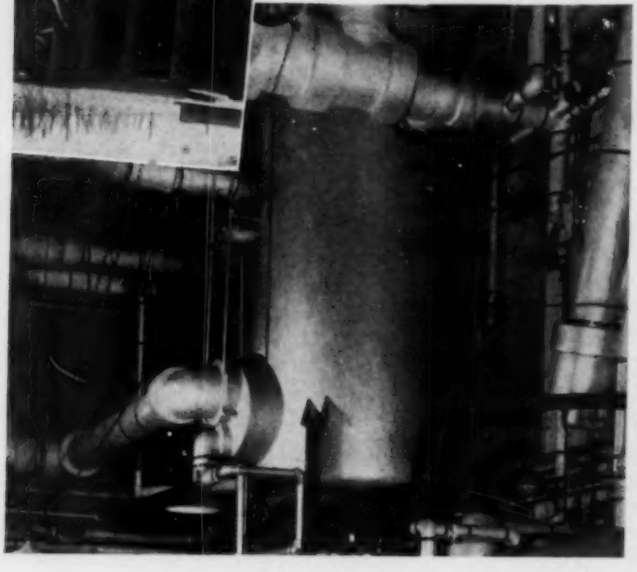
Whitlock-Everdur Heater at KYW Studio, Philadelphia. Woolston-Woods Company, Plbg. & Htg. Contrs.



Every building, from a radio station to a hospital, likes clean hot water provided by Whitlock-Everdur Heaters.

New Bulletin 40 describes these heaters — address — The Whitlock Manufacturing Company, 44 South Street, Hartford, Conn.

Whitlock Everdur Heater at Rhode Island Hospital, Providence. D. D. Eames, Consulting Engineer, Boston.



Booklets, Reports and Papers

Flow of Sludges in Pipes

In the design of pipe lines through which sludge will flow, or must be pumped, there is a lack of sufficient information to make possible precise estimates of the head losses due to friction. In the pumping of sewage sludges the problem has usually been handled by assuming that the common hydraulic formulas applicable to the flow of water may be used in the case of the flow of sludge, provided the velocity of flow of the sludge is great enough to create turbulence. Actual measurements of head losses resulting from the flow of sludge in a pipe indicate that such an assumption is only an approximation of the true conditions which exist.

The purposes of the investigation described in Bulletin No. 319 of the Engineering Experiment Station of the University of Illinois, entitled Laminar Flow of Sludges in Pipes with Special Reference to Sewage Sludge, by H. E. Babbitt and D. H. Caldwell, which has just been issued, were to formulate the various factors that influence the frictional losses when a sludge is pumped through a circular pipe, to formulate the variable factors that affect the critical velocity, to verify the formulas experimentally, and to present a simple method for measuring the characteristics of individual sludges.

As a result of the investigation it has been shown that sludges such as mixtures of clay and water used in deep well boring, sewage sludges, sludges from water softening plants, and other similar aqueous suspensions of fine particles, obey the fundamental formula for the flow of a true plastic.

It has also been shown that for a sludge flowing in a circular pipe a critical velocity is encountered, below which the flow is laminar, and above which the flow is turbulent. This critical velocity does not always occur at the same velocity in a given pipe with a given sludge.

Two formulas have been developed and verified experimentally, one of which gives a velocity, that has been called the "lower critical velocity," below which the flow will always be laminar, and the other a velocity, that has been called the "upper critical velocity," above which the flow will always be turbulent. Between these two velocities the flow may be either laminar or turbulent, or a combination of the two, depending on various factors which are involved.

Until September 1, 1940, or until the supply available for free distribution is exhausted, copies of this 60 p., 6 x 9 in. bulletin may be obtained without charge upon application to the Engineering Experiment Station, Urbana, Ill.

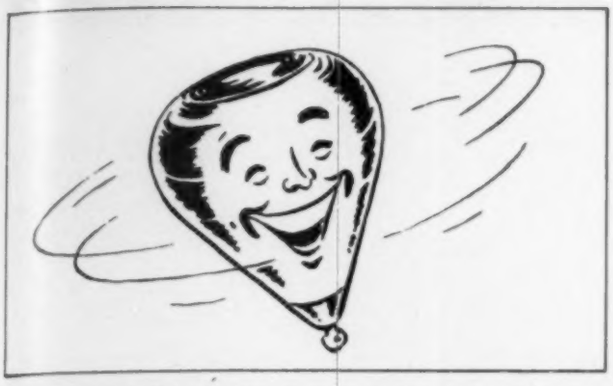
Automatic Refrigerant Control

A new booklet entitled The Handbook of Automatic Refrigerant Control has been compiled and published by the Alco Valve Co., 2628 Big Bend Blvd., St. Louis, Mo. Written in an "easy to understand" manner for the refrigeration man, it contains tables, service data, application drawings, practical definitions and other information.

Definitions of air conditioning and refrigeration terms that every refrigeration man ought to know are included. Valuable tables and equivalents on specific heats, pressure, pressure drop, temperature, latent heats, etc., are provided in a form for easy reference. A service manual or "trouble analyzer" section is particularly interesting and valuable to the repair and service man. Other subjects covered are thermostatic expansion valves, ammonia valves, magnetic stop valves, pressure drop, etc.

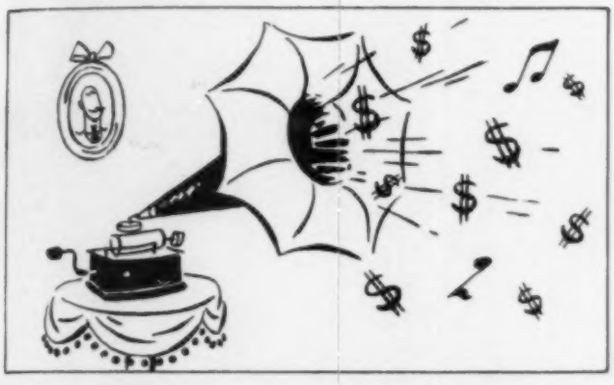
The price of this 76 p., 5½ x8 in., paper covered booklet is 50c. However, it is being distributed by jobbers for a limited time free of charge to purchasers of its publisher's small valves.

File this under "... New Installation ... Air Conditioning"



1 To every worker in the plant, you'll be tops in the management, now that you've decided to install air conditioning. Clean, properly conditioned air is just as necessary to worker-comfort and efficiency as non-skid floors, good light, and modern toilet facilities. *Congratulations!*

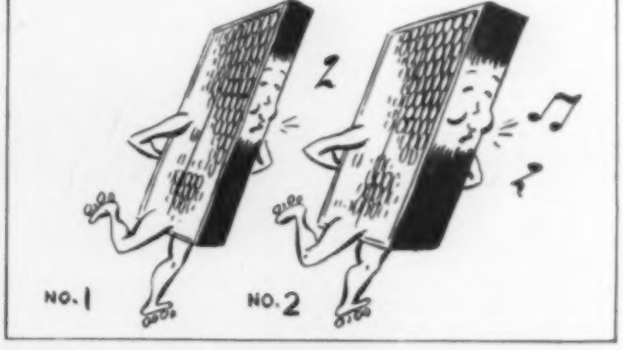
2 And the brass hats themselves will count you a Solomon for choosing efficient Dust-Stop* Air Filters for your new installation. Capacity: 2 CFM per sq. in. of area at 300 FPM. Resistance (in inches of water gauge per inch of depth): .045 to .050 clean to .11 to .12 dirty. They stop virtually all "nuisance" dusts!



3 And Dust-Stops will declare dividends of savings for *you!* They cost approximately 1 cent per CFM to install, including frames—less than 1/10th cent per CFM when filters need changing. *Read on* for other advantages over permanent and mechanical filter installations!

4 As far as Dust-Stops go, you can send the plant firemen out into the fields to pick daisies. Dust-Stops are *safer* because the all-glass Fiberglas* filtering medium and the patented adhesive *will not support combustion.* But that's not all by a long shot. See picture 5.

5 A woman couldn't change her mind any easier than you can change Dust-Stop Air Filters. No skilled work required. These filters eliminate cleaning, charging, draining, expert supervision, and the need to keep a supply of spares. Dust-Stops fit all types of "L" and "V" frames, too.



6 Your air conditioning manufacturer, dealers and jobbers of this equipment everywhere, always have plenty of Dust-Stops on hand. You can get your supply of No. 1's (1-inch) or No. 2's (2-inch) at a moment's notice. So think it over, Mr. Plant Engineer, and specify *replaceable* Dust-Stops in that new installation.

FIBERGLAS* DUSTOP* AIR FILTERS

*T. M. REG. U. S. PAT. OFF.

Made by Owens-Corning Fiberglas Corporation, Toledo, Ohio

U. S. Patents 1,991,455 and 2,050,968. Canadian Patent 360,816. Other Patents Pending.

RIC-WIL Insulated PIPE UNITS

PRE-SEALED UNITS for underground steam lines, in standard pipe lengths, complete with steam pipes and all accessories.

ARMCO HEL-COR CONDUIT AND FITTINGS of heavy gauge pure ingot iron, heavily galvanized, with protective asphalt coating and asbestos-asphalt felt wrapping to resist all forms of deterioration.

WATER-TIGHT, light in weight, yet amply strong to stand abnormal stress and strain, even in shallow trenches.

INSULATION—any standard material in recommended thickness may be specified, such as 85% magnesia or laminated asbestos spongefelt sectional coverings. Asbestos fibre, hand moulded insulation with roofing jacket, can also be furnished.

COUPLINGS which connect units are positive and subject to complete inspection at all times. No guess work involved.

PIPE SUPPORT GUIDES (semi-steel rings carried in special cement insulation) are threaded into each end of the Hel-Cor Conduit, to give permanent pipe alignment, and seal ends of units. These supports are locked securely in place but may be unscrewed (see illustration).

A correctly engineered system built by manufacturers of 30 years' standing, Ric-wiL Insulated Pipe Units are the culmination of experience gained in the production of over 700 miles of underground steam lines. New complete Catalog No. 40, describing all Ric-wiL Systems, sent on request.

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2 *New* STEAM TRAPS

● Now you can get a low priced steam trap that stays on the line, does not clog with dirt and scale and also has unusually high condensate capacity. These two traps, Anderson Super-Silvertop No. 19 (left) and No. 20 (right) are the newest traps in the Super-Silvertop line, superseding Nos. 11 and 12. Notice that case and head are joined with a flanged type connection instead of the bolt construction of traps Nos. 11 and 12. Other changes are the drain plug, greater dirt handling ability, increased pressure range (to 200 pounds per square inch), new valve and lever mechanism without pins or pivots and greatly increased condensate capacity. Yet Nos. 19 and 20 sell at the same price as Nos. 11 and 12.

Traps Nos. 19 and 20 also have guided bucket, simplified piping (elbow or straight-in-line) in one trap, inspection without taking trap from the line. They can be equipped with Thermal Air Eliminators for instant air removal. Write today for capacities and prices.

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Summer Air Conditioning by Gas

A discussion from the gas utility's viewpoint on market possibilities and equipment available for summer air conditioning by gas was presented by Allan W. Lundstrum, Ebasco Services, Inc., at the recent midwest industrial gas sales conference of the American Gas Association. Mr. Lundstrum also delivered this paper at the AGA annual convention last fall.

In concluding the first part of his paper, Mr. Lundstrum summarized it as follows:

1) Summer air conditioning may be added to any desired degree without increasing the peak requirements of the system.

2) Summer air conditioning may be expected to yield a maximum possible load of from 250 to 25 per cent of total possible heating load, depending upon the degree day deficiency of a particular territory.

3) Summer air conditioning may be expected to yield up to a maximum of about 800 therms per average customer per season for an annual degree day deficiency of 500 to not more than 300 therms per average customer per season for degree day deficiency of 6500 per year.

4) The natural gas industry might possibly increase its total sales as much as 25 per cent by complete saturation of the summer air conditioning market, or an increase in annual net of $110,000,000 (50 per cent).

5) The manufactured gas industry might possibly increase its total annual sales 50 per cent by complete saturation of the summer air conditioning market, or an increase in annual net of $110,000,000 (60 per cent).

6) The entire gas industry might expect a maximum of 7,000,000,000 therms per year from complete saturation of the summer air conditioning market, or an increase in annual net of $220,000,000 (55 per cent).

It is not presumed that these figures will ever be reached, he said, but they do represent the order of magnitude of summer air conditioning load possibilities.

Part 2 of his paper was devoted to equipment available for summer air conditioning by gas. In concluding this section Mr. Lundstrum said that great strides had been made in the development of gas fired summer air conditioning equipment during the past few months and that the gas industry may look forward in the near future to having a number of different types of good equipment to use in the development of its summer air conditioning load. He stated that the expectations of profit to both utilities and manufacturers are tremendous and that the rich rewards that summer air conditioning hold out to the gas industry make an intensive effort to develop this load fully worthwhile.

Air Conditioning Helps Product and Worker

Air conditioning was hailed last month by L. Logan Lewis, vice-president of Carrier Corp., as an industrial improvement that "not only improves the product, but also gives the fellow behind the machine a break."

Speaking before the annual meeting of the Society of Chemical Industry in Montreal, Mr. Lewis pointed out that many plants found air conditioning "was an important step in industrial relations as well as a means of improving products and speeding output."

"In modern production methods there are three important parts," he explained, "the material, the machine and the operator. In the case of a manufacturer of silk stockings, for instance, all three of these get a break.

"Low humidity is maintained for working the fiber. Cooling is provided to protect the machines from overheating, and the machine operator has clean, cool, dehumidified air in which to work. This not only makes her more efficient, but also makes her a happier, healthier and better worker."

In addition to improving silk stocking manufacture and helping the worker, air conditioning has brought results to the "man in the street" through its application in various industries to improve products and lower selling costs of staples, he said. "These include cigars," he added, "because today Vice-president Marshall would find that air conditioning has made his dream of a good five cent cigar come true. Humidity control in tobacco factories has brought the costs of cigar making further down each year."

NOISE ELIMINATED IN CANAL BANK BUILDING'S DUCTS

One of the South's largest air-conditioned office buildings provides quiet, fire-safe air-conditioning ducts with more than 15,000 feet of J-M Airacoustic Sheets

CANAL BANK BLDG., New Orleans, La. . . . one of the largest air-conditioned office buildings in the southern United States. More than 15,000 feet of J-M Airacoustic Sheets were used by Weil and Moses, engineers, to keep ducts quiet and fire-safe.

IN planning the huge air-conditioning system for the Canal Bank Building, New Orleans, La., engineers Weil and Moses took no chances with tenants' comfort and safety.

At a surprisingly low cost, all ducts were lined and the fan rooms soundproofed with J-M Airacoustic Sheets.

This modern lining material eliminates more than 70% of all sounds in the ducts. Its mineral base will not support flame . . . prevents the spread of fire through the duct system. And, because Airacoustic Sheets are strong, durable, highly moisture-resistant, maintenance will never be a problem.

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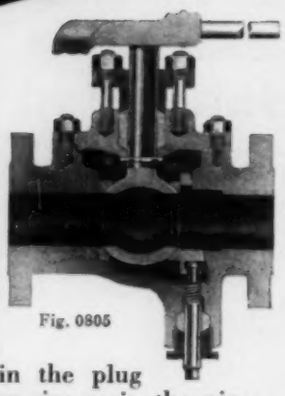

Fig. 0805

The shearing action of the rotating ball plug in Sphero Valves cuts through scale or thick viscous materials as it revolves when opening or closing. This, and the perfect seating of the ball, assures a tight, leak-proof seal.

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Conventions and Expositions

Midwest Power Conference: April 9-10, Palmer House, Chicago, Ill. Under direction of Stanton E. Winston, 401 S. Quincy St., Hinsdale, Ill. Sponsored by Armour Institute of Technology and other colleges and societies. Includes sessions on small power plants; electrical transmission; power for paper mills, refineries, and chemical plants; fuel problems; and hydro power.

Heating and Air Conditioning Conference: April 9-11, Iowa State College, Ames, Iowa, and display of heating and air conditioning equipment. Program includes papers on oil burners, stokers, noise, air filter performance, the electrostatic filter, air distribution, and determining the cooling load on small commercial installations.

International Acetylene Association: Annual convention, April 10-12, Schroeder Hotel, Milwaukee, Wis. Headquarters office, 30 E. 42nd St., New York, N. Y. Papers to be presented afternoon of April 10 include discussions of welding carbon-molybdenum pipe and welding industrial piping.

American Society of Mechanical Engineers: Spring meeting, May 1-3, Hotel Bancroft, Worcester, Mass. Headquarters office, 29 W. 39th St., New York, N. Y. Papers to be presented include Feedwater Treatment, by C. H. Fellows; Experimental Drying, by D. L. Cooper; Thermometric Time Lag, by R. Beck; Conditioned Air in Drying and Curing of Tobacco, by A. H. Cooper; Burning of Heavy Fuel Oil, by G. C. Martinson; Purchase and Use of Fuels, by E. Wadsworth Stone; Recent Developments of Oil Burners, by R. C. Vroom; Comparative Tests of Flow Measurements, by O. H. Dodkin; Thermodynamic Properties of Vapors, by Eric Leib; and The New Specific Heats, by R. C. H. Heck.

Anthracite Conference: May 9-10, Packard Auditorium, Lehigh University, Bethlehem, Pa. Program includes papers on research and radiant heating.

National District Heating Association: Annual meeting, May 14-17, French Lick Springs Hotel, French Lick, Ind. Secretary-treasurer, John F. Collins, Jr., 1231 Grant Bldg., Pittsburgh, Pa.

Smoke Prevention Association: Annual convention May 21-24, Hotel Statler, St. Louis, Mo. Headquarters office, City Hall Square Bldg., Chicago, Ill.

International Petroleum Exposition: May 18-25, Tulsa, Okla.

Heating, Piping and Air Conditioning Contractors National Association: Annual convention, May 27-30, Hotel Pennsylvania, New York, N. Y. Secretary, Joseph C. Fitts, 1250 Sixth Ave., New York, N. Y. Program includes report on preparation of test material for apprentice training courses, welding committee report on standard procedure for electric arc pipe welding, discussion on air conditioning and trade promotion, introduction of IBR ratings on cast iron boilers, and committee reports on legislation and separation of contracts, certification and standards.

National Warm Air Heating and Air Conditioning Association: Mid-year meeting, June 3-5, Palmer House, Chicago, Ill. Managing director, Allen W. Williams, 5 E. Long St., Columbus, Ohio.

Stoker Manufacturers Association: Annual meeting June 6-7, Homestead Hotel, Hot Springs, Va. Headquarters office, 307 N. Michigan Ave., Chicago, Ill.

American Society of Refrigerating Engineers: Spring meeting, June 9-11, Skytop Lodge, Skytop, Pa. Secretary, David L. Fiske, 37 W. 39th St., New York, N. Y.

American Society of Heating and Ventilating Engineers: Semi-annual meeting, June 17-19, Wardman Park Hotel, Washington, D. C. Secretary, A. V. Hutchinson, 51 Madison Ave., New York, N. Y.

National Association of Building Owners and Managers: Annual convention, June 17-20, Commodore Hotel, New York, N. Y. Headquarters office, 134 S. La Salle St., Chicago, Ill.

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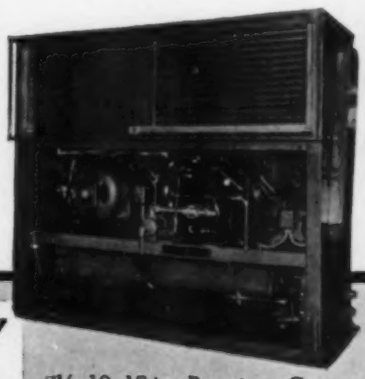

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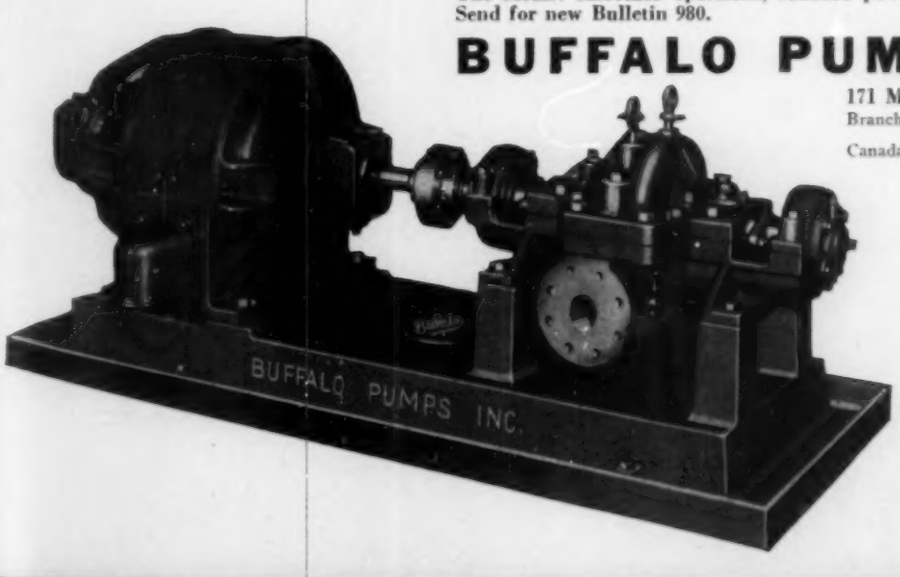

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Book Reviews

ASTM Publishes Book of Standards

[ASTM Standards 1939, in three parts—Part I, Metals; Part II, Non-metallic Materials—Constructional; Part III, Non-metallic Materials—General. 1308 + xxvi, 1217 + xxvii, and 1175 pp. + xx, respectively. 6 x 9 in. Published by American Society for Testing Materials, 260 S. Broad St., Philadelphia, Pa. Prices (clothbound): any one part $8.00; any two parts $15.00; all three parts $22.00. Supplements for 1940 and 1941: any one part, $3.00; any two parts $5.00; all three parts $7.00. For half-leather binding add $1.00 for each part and each supplement.]

Publication work on the 1939 Book of ASTM Standards has recently been completed and copies of this important publication are now available. Important changes are incorporated in this latest ASTM publication. For the first time, it contains all of the society's specifications, whether standard or tentative. Formerly the tentative specifications were issued in an annual volume, but the convenience of having these and the formally adopted standards in one volume led to the present combination. The book is in three parts, instead of two parts as formerly, Part I covering metals; Part II, Non-metallic Materials—Constructional; Part III, Non-metallic Materials—General. The divisions are as follows:

Part I. Metals—Ferrous and non-ferrous metals, except methods of chemical analysis. General testing methods.

Part II. Non-metallic Materials—Constructional—Cementitious materials, concrete, masonry building units, ceramics, pipe, timber and preservatives, paints, road materials, waterproofing materials, soils, general testing methods.

Part III. Non-metallic Materials—General—Fuels, petroleum products, electrical insulating materials, rubber, textiles, soaps and detergents, paper, plastics, water, general testing methods, thermometers.

Each part contains a complete subject index and there are three tables of contents, designed to make the book of maximum utility. The first lists items under the general materials covered; following this is a table of contents giving a complete list of all the items in the part by numeric sequence. The third table covers by subject the tentative standards, which appear in the back portion of each part. These tentative specifications are proposed standards in widespread use throughout industry.

Practically all of the specifications and tests have been reset in the new double column format. This use of new type gave all of the society's committees an opportunity to review the some 866 items included and incorporate a number of editorial improvements. This work has been going on for months in coöperation with the ASTM staff.

Another departure in the mechanical features of the books involves a newly designed backstrap to give them a distinctive and attractive appearance.

The society continues the publication of its volume on chemical analysis of metals including 19 methods covering 250 pages. This book is of interest to special groups and the material has not been included in the Book of Standards.

The method of issuing the 1939 Book of Standards also provides that a supplement to each of the three parts will be issued in 1940 and 1941. These volumes (estimated pages 350 to 500 each) will contain all new and revised standards and tentative standards, and revisions, approved in the respective years.

There are 866 separate standard and tentative specifications, methods of test, definitions, etc., in the three parts, with 28 duplications (primarily between Parts II and III). The number of items in each part is as follows: Part I, 298; Part II, 351; Part III, 245.

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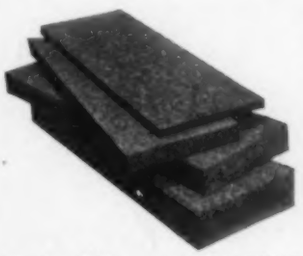

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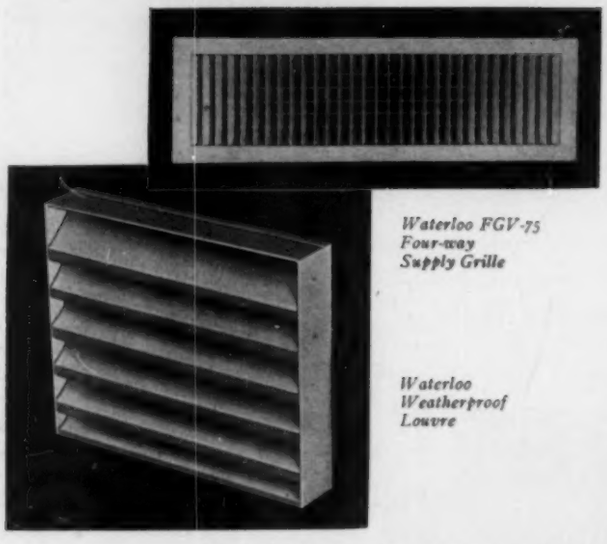

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Equipment Developments

For your convenience in obtaining more information about any of this equipment, see coupon on page 134. Add the new products and companies listed here to your Directory Section which you received in your January, 1940, HEATING, PIPING AND AIR CONDITIONING and thus keep your records of sources of supply up to date throughout the year . . . Single asterisk (*) indicates equipment not listed in Directory Section; double asterisk (**) equipment and manufacturer not listed

Controllers for Temperature, Pressure, Flow and Liquid Level

No. 1824—A redesigned line of "Fulscope" air operated recording and indicating controllers for temperature, pressure, rate of flow and liquid level has been introduced. In addition to combining in one instrument the proportional response and automatic reset forms of control, these new controllers incorporate a third process control effect, namely, "Pre-Act," the manufacturer states. This is a supplementary control feature which makes control valve corrections according to the rate of control point deviation. In response to sudden disturbances in the process or variations in the controlling medium, over-peaking or oscillating is reduced by an immediate and relatively larger control valve action than would occur otherwise. Furthermore, states the maker, this feature stabilizes operation after a change in set point and when the equipment is started up.

The automatic reset feature, which compensates for changes in load, is situated in the instrument case and is fully adjustable over a wider range than previously.

The universal die-cast aluminum case is adaptable to face or flush mounting. Recording instruments are available with two complete control mechanisms with any combination of actuating systems except two manometers. Interchangeable unit construction permits conversion from one form to another in the field.

These controllers are available in five standard types: fixed high sensitivity; adjustable sensitivity; adjustable sensitivity with automatic reset; adjustable sensitivity with "Pre-Act"; and adjustable sensitivity with automatic reset and "Pre-Act."—Taylor Instrument Companies, 95 Ames St., Rochester, N. Y.

Redesigned Air Conditioner Line

No. 1825—The "Climate Changer" air conditioner line has been redesigned and refined to incorporate the latest developments in the air conditioning field and to include all of the maker's unit coolers and air conditioners under the single designation. The line has been expressly planned to afford a unit selection for practically every known air conditioning purpose, the manufacturer states. Five major types possess a diversity of application possibilities as well as capacity range from 250 to 20,000 cfm.

The various available types are as follows:

Type D includes a group of air conditioners for a wide variety of applications. Sizes range from small horizontal and vertical models for hotel and office application to large commercial units manufactured in three parts and capable of delivering a maximum of 20,000 cfm. The models afford a wide range of fan and coil capacity and are available in various coil combinations for the different types of winter heating and summer cooling.

Type A units are designed expressly for apartment house applications—for individual apartment air conditioning. Available in both vertical and horizontal models, these units may be placed in a closet or other out-of-the-way spot or furred into the ceiling. Capacities from 300 to 1600 cfm.

The Type F is a floor unit which provides year 'round air conditioning for home or office. Furnished in a neutral color to blend with the decorations of any interior. Available in a range of sizes and capacities from 250 to 1500 cfm.

The Type M is especially for installations where economy is the deciding

factor in the selection of equipment. All essential features of complete air conditioning are incorporated. Available in both vertical and horizontal models in various sizes ranging in capacity from 1200 to 12,500 cfm. Horizontals utilize single fan, and the vertical units are furnished with twin fans.

The Type X is a propeller comfort cooler for spot cooling. Capacities from 530 to 2250 cfm.

The sprayed coil unit is designed especially for a built-up system requiring a separate fan motor and drive and filters. Because its coils are sprayed, it provides air washing in winter or summer. During the heating cycle, either steam or hot water may be used with humidification obtained by means of washer type spray nozzles. During the summer, cold water, brine or direct expansion refrigerants may be used for cooling, with dehumidification obtained with the cooling coils. Capacities from 2000 to 48,000 cfm.—Trane Co., La Crosse, Wis.

Automatic and Thermostatic Expansion Valves

No. 1826—The new "Dura-fram" expansion valves recently announced are of single diaphragm construction, the diaphragm joints being silver soldered and the diaphragm of stainless steel. Needles and seats (removable on the adjustable thermostatic types) are made of "Delubaloy," a corrosion resisting alloy.

This new line of valves includes both automatic and thermostatic types. A feature of the thermostatic types is that they combine the benefits of gas charged power elements with single diaphragm construction, the maker states. Gas charging limits the suction pressure when starting up the system, according to the maker.

The valve body is at the temperature of the high pressure liquid; therefore, the bulb automatically stays colder than the valve. Thus the valve may be installed even where the valve body is located within the cooled space. In the larger sizes, the high side liquid is precooled before reaching the orifice in order to reduce the volume of any entrained gas and pass a solid stream through the orifice.

Capacities of the larger valves may be changed on the job by changing the selective capacitators or the seat assembly.—Detroit Lubricator Co., 5900 Trumbull Ave., Detroit, Mich.

Combination Starter and Motor Disconnect Switch

No. 1827—A new combination across the line starter and motor disconnect switch for use with squirrel cage and single phase motors has been developed. According to the manufacturer, front operation allows close ganging of a number of units in compact width and height multiples; and combining the starter, switch and fuses in one enclosure saves wiring and conduit work. By loosening four screws the entire control panel may be removed.

The front operated, contactor type disconnect switch incorporates "Dust Safe" vertical contacts which are interchangeable with the starter contacts. Overload protection is provided by a thermal overload relay. The mechanical door interlock prevents opening the door when the disconnect switch is closed.

This starter is available with either three or four poles, in five sizes, horsepower ratings from 6½ to 200, and with the following types of cover control: reset button only, start and stop reset buttons, or three position selector switch for manual-off-automatic-local control. The starter can be furnished in water tight, dust tight and in NEMA Type 7 and 9 enclosures for hazardous locations.—Cutler-Hammer, Inc., N. 12th St. and W. St. Paul Ave., Milwaukee, Wis.

New Meter of Area Type

No. 1828*—A new type of meter (the "Linameter") is adapted particularly to the measurement of fluids having characteristics of viscosity, corrosiveness, and solubility such as fuel oil, ammonia, hot tar, etc., according to the manufacturer. This meter is of the area type, with meter body installed as an integral part of the pipe line, and containing a weighted disk

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USAIRCO blowers fit into every system and into every budget. There's a size and type for every need at a price that makes USAIRCO blowers the most profitable equipment on the market. They are the result of 16 years of progressive engineering and specialized manufacture. All USAIRCO air conditioning equipment is fully guaranteed as to ratings and performance. USAIRCO is equipped to give fast service on special items. Write for details.

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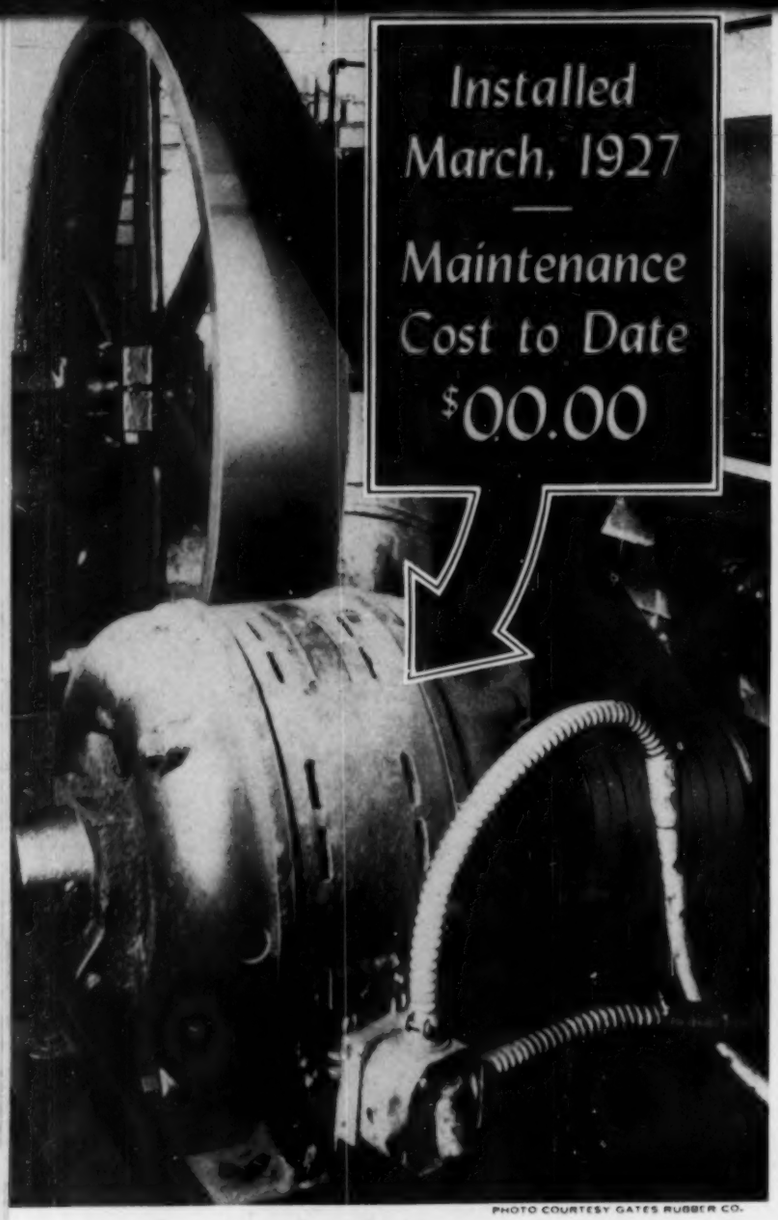

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The *standard* HOWELL 15 HP, 1200 RPM Motor shown above has just rounded out 13 years of continuous service. It is installed at the Suabedissen-Wittner Dairy, South Bend, Indiana, driving a 15-ton ice machine under severe load conditions.

Not once in 13 years has this motor been out of commission—never required a single repair. Recently we checked it thoroughly — STILL O.K.

Yes, Sir, HOWELL Motors can take PLENTY of punishment year in and year out! That's undoubtedly the main reason why they are used so extensively in air conditioning on all types of drives. They ARE dependable!

FAST DELIVERY ON ANY DESIRED QUANTITY

IMMEDIATE ENGINEERING SERVICE

YOUR NEEDS - STANDARD OR SPECIAL?

HOWELL makes all types of air-conditioning motors, ½ to 150 HP — a goodly share of them SPECIAL motors. If you have ANY drive problem, and want FAST ACTION, direct your inquiry our way. Even though special, we can produce your job immediately—NO DELAY. *At HOWELL, real service and finest quality go hand in hand.*

1915 · 1940 HOWELL MOTORS 25th Anniversary Year

OWELL ELECTRIC MOTORS COMPANY
HOWELL, MICHIGAN
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positioned by the velocity of fluid through a tapered throat section in such a manner that the disk travel is directly proportional to flow rate. Attached to the weighted disk is a rod and iron core, the latter of which traverses the field of two reactance coils surrounding the pressure tight tube of the meter body. These coils form a reactance bridge when connected electrically to similar coils in the indicating, recording and integrating instrument and form the means of transmitting the measurement to any desired distance from the meter body. Measurement is accomplished in the recording instrument by use of the galvanometer null principle, as applied to the maker's electric flow meter.

The meter is made in different combinations of indicating, recording and integrating features to suit particular conditions and may be equipped with pressure and temperature elements to record on the same chart with flow. Styles are available for wall, column or flush panel mounting.—Cochrane Corp., 3161 N. 17th St., Philadelphia, Pa.

New Centrifugal Fan

No. 1829—Low power consumption, quiet operation and little maintenance characterize the latest addition to the line of centrifugal "Silentvane" fans, according to the maker. Known as "Design 7," this fan is constructed of heavy steel plate reinforced with angle irons.

Quiet operation results from streamline inlets shaped to form whirlfree passages for the air to enter the rotor smoothly, reducing fan eddy currents and turbulence. Mechanical efficiencies in excess of 70 per cent are obtained over 53 per cent of the performance range, 75 per cent over 41 per cent of the performance range, and 80 per cent over 21 per cent of the performance range, the manufacturer states. The fan has a self-limiting horsepower characteristic with gradually increasing horsepower and volume until the point of maximum efficiency is reached; then decreasing horsepower for larger volumes. Straight fan blades pitched at an angle of 45 deg at delivery are designed for freedom from dust loading in rotors or fouling when handling dirty gas or air.

This fan is available in all standard discharges, single and double width, single and double inlet, with wheel diameters ranging from 14⅝ to 87 in., static pressures to 16 in. water gage.—B. F. Sturtevant Co., Damon St., Hyde Park, Boston, Mass.

Magnetic Switch for Air Conditioning

No. 1830—A new magnetic switch for control of air conditioning equipment motors directly from the contacts of a room thermostat or other low voltage control instrument has been announced. This unit (which has application in most situations where it is desirable to control air conditioning equipment motors from a thermostat, the maker says) consists of a three pole magnetic switch mechanism, overload relays, and a low voltage control transformer assembled into one compact unit.

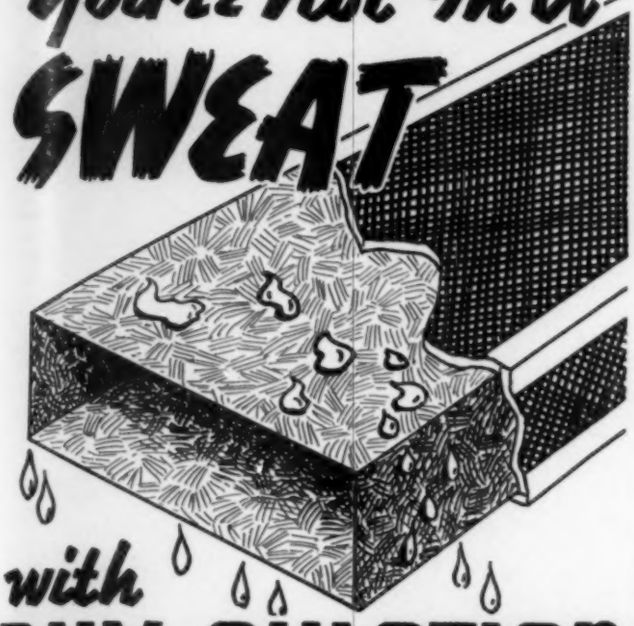
This magnetic switch and transformer combination protects a motor against overload by means of its manual or automatic reset overload relays, and also, with its low voltage control terminals on the outside of the enclosure, assures isolation of the pilot circuit from the power wiring.

A normally open interlock is furnished to provide correct sequencing with other equipment when desired. The operating coil is isolated electrically from the power circuit, providing flexibility for wiring.—General Electric Co., 1 River Rd., Schenectady, N. Y.

Water Regulating Valve

No. 1831—A new development in water regulating valves is the "Model 68 Series" introduced recently. Designed principally to control the flow of water to water cooled compressors and condensing coils by means of head or receiver pressure, it may be used on either "Freon," methyl chloride or sulphur dioxide systems.

You're Not In A SWEAT



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1938 . . 1 THEATRE
1939 . . 7 THEATRES
1940 . . (TO DATE) 3 THEATRES

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☐ Auto Technician		☐ Sheet Metal Work
☐ Aviation	☐ Highway Engineering	☐ Steam Electric
☐ Boilermaking	☐ House Planning	☐ Steam Engines
☐ Bridge Engineering	☐ Machinist	☐ Steam Fitting
☐ Building Estimating	☐ Mechanical Drafting	☐ Structural Drafting
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Available in ⅜, ½ and ¾ in. female iron pipe size inlet and outlet connections, the valve has an adjustable head pressure range from 60 to 130 lb per sq in. Head pressures at which the valve is set to open are dependent on water temperature and type of refrigerant used. Adjustment is made on an accessible adjustment screw below the body shell, which slides off for adjustment purposes.

Construction of the valve is of interest. A molded composition seal on the valve stem operates against a polished stainless steel seat. The seat is so constructed that during operation it cleans the valve seal to eliminate possibility of leakage at this point due to corrosive deposits, dirt and other foreign matter, according to the manufacturer. The valve stem is packless and bellows sealed. Valve bodies are "streamlined" in design to provide greater installation space.

Based on average compressor rating, the ⅜ in. size will handle approximately 3 hp on commercial applications; the ½ in. size, 6 hp; and the ¾ in. size, 12 hp. These figures are based on a water temperature rise of 15 deg and a pressure differential of 10 lb across the valve.—Automatic Products Co., 2460 N. 32nd St., Milwaukee, Wis.

Balanced Type Relay

No. 1832—The "Polarized Microrelay" is a new balanced type relay which may be used in either a-c or d-c circuits.

It has many applications, the maker states, one of the most common being in self-balancing bridge circuits for positioning motor operated devices from either manually or automatically positioned potentiometers. Another important application is in the high temperature instrument field where a proportioning type potentiometer controller is used to position a motor operated valve. It can also be used as a voltage or current sensitive relay, and as a conventional relay to protect delicate contacts in other circuits.

The movement of the tongue between the contacts is governed by four coils contained in the solenoid cylinder. An armature is suspended horizontally in the axial center of this cylinder and when it is affected by a magnetic pull at either end of the cylinder, because of an unbalanced condition in the bridge circuit, this motion is transmitted to the tongue causing it to move to one or the other of the contacts. This balanced solenoid action permits rugged construction without affecting sensitivity, according to the manufacturer.—Barber-Colman Co., 225 Loomis St., Rockford, Ill.

Recent Trade Literature

For your convenience in obtaining copies of these bulletins, see coupon on page 134. If you write direct to the manufacturer, describe carefully what literature you want, as the number given first in each item is for use only when sending your request to HEATING, PIPING AND AIR CONDITIONING.

No. 3468. AIR CONDITIONERS: The Trane Co., La Crosse, Wis. 76 p. data bulletin (D303-2) with complete description, specifications, capacities, and dimensions on "Climate Changers," sprayed coil units, and engineering information on coil selection, water friction and water velocity. (Available only to architects, engineers and contractors).

No. 3469. BEARING BRONZE: Johnson Bronze Co., 460 S. Mill St., New Castle, Pa. 76 p. catalog (400) listing and describing over 800 sizes of plain bearings and 350 bronze bars. Many new items have been added to the electric motor bearing section.

No. 3470. BOILER RATINGS: Utica Radiator Corp., 2201 Dwyer Ave., Utica, N. Y. 8 p. booklet on IBR rating program

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Use a Dart Union once, twice, time and again. Each time you reinstall it, **cost-per-tight-joint** goes down. That's the whole story of Dart economy. Plus, of course, the fact that Dart's **repeated use** is built on two bronze seats ground to a true ball joint that stays true to form in tough service—air-refined malleable iron bodies and nuts that resist stretch—extra "heft" that prevents damage from pipe strains and wrench abuse. It will pay you well to send for a Dart to try—free.

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Sarco cuts replacement costs—on steam presses

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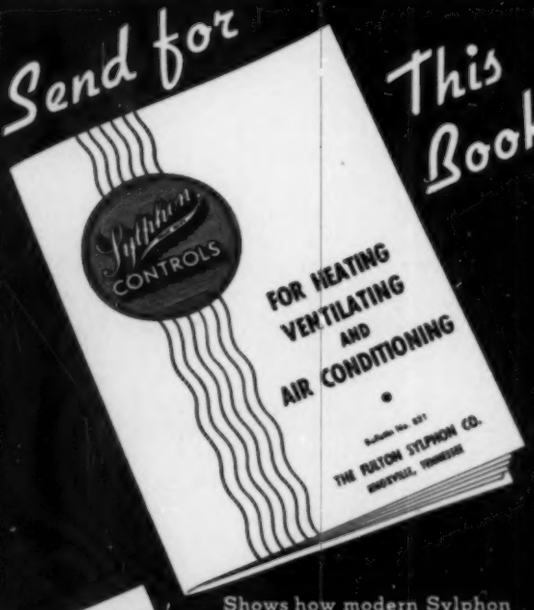

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A new two-wire hydraulically operated, full-ported, *all-purpose* motor valve for air, water, gas, gasoline, oil (any gravity and grade) brine, or saturated steam up to 150 lbs. per sq. inch, and 125° F. to 250° F.

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for cast iron boilers, a scientific and uniform method of rating designed to provide a practical basis for selecting boiler sizes.

No. 3471. CAPACITOR MOTORS: General Electric Co., 1 River Rd., Schenectady, N. Y. 8 p. bulletin (GEA-2915A) on general purpose capacitor motors describing applications, construction, characteristics, modifications, ratings and advantages.

No. 3472. DAMPERS AND DAMPER REGULATORS: Young Regulator Co., 4500 Euclid Ave., Cleveland, Ohio. 8 p. catalog (1) on dampers, damper regulators, remote control regulators and accessories, showing manufacturer's complete line.

No. 3473. ELECTRIC HEATERS: Electric Air Heater Co., Div. of American Foundry Equipment Co., 555 Byrkit St., Mishawaka, Ind. 2 p. bulletin (15) on "Electromode" industrial portable electric heaters, giving specifications, dimensions, capacity ratings and features.

No. 3474. FIRE BRICK: A. P. Green Fire Brick Co., Mexico, Mo. 4 p. folder describing "Empire" fire brick, its advantages and uses.

No. 3475. GAS ENGINES: Worthington Pump & Machinery Corp., Harrison, N. J. 8 p. bulletin (S-550-B7) on vertical four cycle gas engines with 25 in. stroke, illustrating and describing features and giving dimensions and specifications.

No. 3476. HEATING AND AIR CONDITIONING APARTMENTS: Trane Co., La Crosse, Wis. 12 p. issue of "Weather Magic" (Vol. 3, No. 11) on heating and air conditioning apartments, including general discussion of the problem, heating by hot water, vapor and vacuum, use of convectors, zoning, use of air conditioning units, and describing central and unit systems and variations of them.

No. 3477. INDUSTRIAL AIR FILTERS: Air-Maze Corp., 5200 Harvard Ave., Cleveland, Ohio. 4 p. bulletin on "Multimaze" industrial air filters for diesel, semi-diesel, gasoline and gas engines; air compressors; pumping units; blowers; air conditioning systems; hydraulic presses, etc.

No. 3478. INSULATION IN AIR CONDITIONING: Philip Carey Co., Wayne Ave., Lockland, Cincinnati, Ohio. Looseleaf service manual covering "Careyduct," an asbestos insulated duct, piping insulation for air conditioning, insulation of metal ductwork with asbestos, and giving specification for construction of air conditioning housings by use of "Firefoil," an insulated preformed panel.

No. 3479. LEATHER BELTING: Alexander Brothers, 406 N. Third, Philadelphia, Pa. 8 p. bulletin (A-13) on "Duplex" leather link belt, a new type, including descriptions of it and its applications, a price list and horsepower and diameter table.

No. 3480. LEATHER BELTING: Chicago Belting Co., 113-125 No. Green St., Chicago, Ill. 24 p. condensed catalog on "tension welded" leather belting, with illustrations and descriptions of manufacturing method and testing, with data on short center drives and description of the various types available, and accessory equipment. Application data are included.

No. 3481. LEATHER BELTING: J. E. Rhoads & Sons, 35 N. Sixth St., Philadelphia, Pa. 4 p. folder about "Tannate Watershed" leather belting, its advantages and features.

No. 3482. MARINE TYPE BOILERS: Kewanee Boiler Corp., Kewanee, Ill. 4 p. bulletin (99-2a) on low pressure Scotch marine type boilers for mechanical firing, giving specifications, measurements and discussion of construction features.

No. 3483. MATERIALS HANDLING: Lewis-Shepard Sales Corp., Watertown, Mass. 56 p. catalog (21) covering 175 of the manufacturer's most important items in their line of materials handling equipment including hydraulic trucks for handling radiators and for other services, stackers, portable cranes, floor trucks, skid platforms, and various other equipment.

No. 3484. MOTOR STARTING SWITCHES: General Electric Co., 1 River Rd., Schenectady, N. Y. 2 p. bulletin (GEA-

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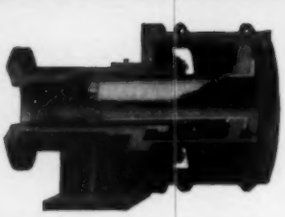

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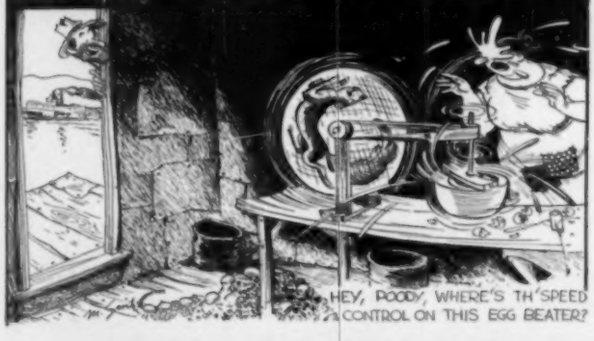

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The Air Filter Indicator Takes the Guess Out of Filter Maintenance.

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YARWAY

1184D) on a-c magnetic motor starting switches for squirrel cage motors, or for use as primary switches for wound rotor motors.

No. 3485. NOZZLES AND NOZZLE ACCESSORIES: Spraying Systems Co., 4021 W. Lake St., Chicago, Ill. Loose-leaf catalog (20) on spray nozzles and nozzle accessories for various purposes including air conditioning, general industrial applications, humidifying, roof spraying, water cooling, etc. Detailed engineering data are included.

No. 3486. ODOR CONTROL: W. B. Connor Engineering Corp., Dorex Div., 114 E. 32nd St., New York, N. Y. Bulletin on "Dorex" odor adsorbers for installation in new or existing air conditioning or ventilating ducts, on inlet or outlet grilles, or on dust filters, including data on capacities and specifications. Also new catalog on subject of controlling odors in air conditioning and ventilation work, including units for central plants and portable units.

No. 3487. PRESSURE CONTROLS: Automatic Control Co., 2590 University Ave., St. Paul, Minn. 8 p. bulletin (T-7) on "Tanktrols" (pressure type controls for elevated tank systems) with information on remote control of water level in tanks and descriptions and illustrations of the controls available.

No. 3488. PROPELLER FANS: Hartzell Propeller Fan Co., P. O. Box 909, Roosevelt Ave., Piqua, Ohio. 28 p. catalog (12) on "Charavay" propeller type fans and blowers, with air delivery tables, descriptions of features, and information on various applications.

No. 3489. ROOM COOLERS: Pleasantaire Corp., Tower Bldg., Washington, D. C. New bulletins on wholesaling packaged air conditioning at a profit, and retailing packaged air conditioning at a profit, presenting a merchandising program. Also a 4 p. bulletin describing and illustrating this manufacturer's room cooler.

No. 3490. SEPARATORS: Cochrane Corp., 17th St. and Allegheny Ave., Philadelphia, Pa. 8 p. bulletin (2950) illustrating and describing baffle type moisture and oil separators for use in vertical or horizontal steam, gas and air lines with engineering data, dimension tables, and drawings.

No. 3491. SHEET METAL WELDING: The Linde Air Products Co., Unit of Union Carbide & Carbon Corp., 30 E. 42nd St., New York, N. Y. 16 p. booklet (4435) on sheet metal welding fundamentals, covering such subjects as design factors, control of expansion and construction, use of jigs, weldability of material and welding procedure.

No. 3492. SHORT CENTER DRIVES: J. E. Rhoads & Sons, 35 N. Sixth St., Philadelphia, Pa. 4 p. folder on "Tannate-Rockwood" short center drives and their advantages, including case histories.

No. 3493. SILVER BRAZING ALLOYS: Handy & Harman, 82 Fulton St., New York, N. Y. 28 p. reprint on silver brazing alloys in the marine field, a paper originally published in the *Journal* of the American Society of Naval Engineers. The principles apply with little or no variation to any work where low temperature silver brazing alloys are to be used.

No. 3494. SOLDERING FLUXES: American Chemical Paint Co., Ambler, Pa. 4 p. bulletin (5) on "Flosol" soldering fluxes.

No. 3495. STEAM TRAPS: Yarnall-Waring Co., Chestnut Hill, Philadelphia, Pa. 16 p. bulletin (T-1735) on "Yarway" impulse steam traps with description and illustrations of features and operation, information on selection, installation and operating instructions, and data on capacities, prices, weights and dimensions. How to determine steam trap efficiency is also discussed.

No. 3496. VALVES: Foxboro Co., 106 Neponset Ave., Foxboro, Mass. 6 p. folder (DMF 789) on "Stabilflo" valves for

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No. 3497. VALVES: General Electric Co., 1 River Rd., Schenectady, N. Y. 2 p. leaflet (GEA-1569B) on "Thrustor" operated valves for pipe sizes 1 to 10 in. inclusive, illustrating and describing features, and giving approximate dimensions.

No. 3498. V-BELTS: Allis-Chalmers Mfg. Co., Milwaukee, Wis. Revised catalog section (151) introducing new horsepower ratings for multiple v-belt drives and giving information on selection of size of belt for horsepower rating, speed, center distances and sheave diameters.

No. 3499. WELDING ELECTRODES: Wilson Welder and Metals Co., Inc., 60 E. 42nd St., New York, N. Y. 24 p. booklet (ADW-18) prepared as a guide for selection of proper arc welding electrodes for various classifications of work. The welding symbols of the American Welding Society are included.

No. 3500. WELDING GUIDE: The Linde Air Products Co., Unit of Union Carbide & Carbon Corp., 30 E. 42nd St., New York, N. Y. Guide to welding commonly used metals and alloys printed in chart form from which the recommended welding method, flame adjustment, welding rod and flux for each of 30 different metals and alloys can be determined.

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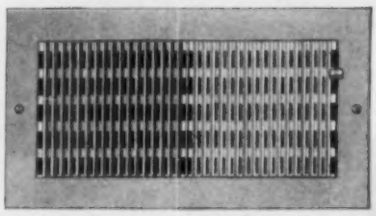

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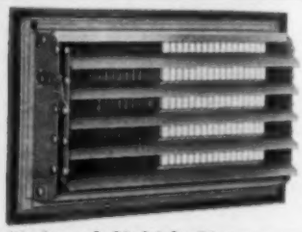

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